FINAL
ENVIRONMENTAL IMPACT STATEMENT

for the

UPPER MAKALEHA SPRINGS WATER RESOURCE DEVELOPMENT
Kapaa, Kauai, Hawaii

DECEMBER 1990

State of Hawaii
Department of Land and Natural Resources
Division of Water Resource Management

DIVISION OF WATER RESOURCE MANAGEMENT
DEPARTMENT OF LAND AND NATURAL RESOURCES
STATE OF HAWAII

This Environmental Document is Submitted
Pursuant to Chapter 343, HRS

FINAL ENVIRONMENTAL IMPACT STATEMENT
UPPER MAKALEHA SPRINGS
WATER RESOURCE DEVELOPMENT
Kapaa, Kauai, Hawaii

PROPOSING AGENCY:

Division of Water Resource Managment
Department of Land and Natural Resources
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ACCEPTING AGENCY:

Governor, State of Hawaii

for

William W. Paty
Chairperson
Board of Land and Natural Resources

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FINAL ENVIRONMENTAL IMPACT STATEMENT
UPPER MAKALEHA SPRINGS WATER RESOURCE DEVELOPMENT PROJECT

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The Hawaii Division of Water and Land Development proposes to tap natural springs on State land in the Makaleha Mountains of East Kauai, and to pipe the water to Kapaa for domestic uses. The project involves the construction of a concrete intake basin and approximately 4000 feet of iron pipe. The proposed project will fulfill the primary purpose of the Kealia Forest Reserve which is to serve as a source of water supply.

Other project alternatives considered included the "no project" option, drilling a new well on Akulikuli Ridge, enlarging existing water tunnels, and the construction of a surface impoundment.

The proposed project will help alleviate existing water shortages in the Kapaa-Wailua area by increasing the overall supply approximately 16%. Adverse environmental impacts include a slight degradation of aquatic habitats and surface water quality, especially during construction. In addition, the project will also include the diversion of water now being used by Lihue Plantation Company to irrigate 1000 acres of sugarcane. These impacts will be mitigated by 1) the use of cement rubble masonry for the intake and pipeline pedestal construction; 2) replanting of exposed riparian areas with indigenous vegetation; 3) the restriction of land vehicles past the mauka end of Kahuna Road; 4) the use of silt fences and fabric material to reduce potential sedimentation; and 5) the scheduling of excavation work during the drier months of May through September.

The project is consistent with the Kauai County General Plan and the Hawaii State Plan.

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INTRODUCTION

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INTRODUCTION

1.1 PURPOSE OF THE PROJECT

This environmental impact statement has been prepared to:

1. Identify and analyze reasonable project alternatives for obtaining an increased potable water supply for the Island of Kauai's Wailua-Kapaa area;

2. Evaluate selected characteristics and trends of the Upper Makaleha Spring Catchment site, the Kapaa Homesteads area, and surrounding Wailua-Kapaa area;

3. Determine and analyze significant environmental consequences which are expected to result from implementation of the selected project alternative; and

4. Identify practical mitigative measures which can reduce the consequences of the proposed water resource development.

1.2 METHODOLOGY

This EIS document contains a combination of quantitative and qualitative analyses which were made to meet the information objectives outlined in section 1.1. These objectives reflect the EIS content requirements outlined in Title 11, Chapter 200 of the Hawaii Revised Statutes.

Analyses relied primarily upon available information and consultation with selected representatives from various public agencies and private organizations in Hawaii (see section 1.3). Available information and agency consultations were supplemented with onsite field surveys, and related evaluations, by several environmental specialists.

An archaeological reconnaissance was conducted along Makaleha Stream in October, 1986. The reconnaissance survey and subsequent evaluations were made by Cultural Surveys Hawaii under the direction of Hallett Hammatt, Ph.D.

In December, 1986, a botanical survey was performed by Char & Associates near the county water storage tank along Kapaa Road to Makaleha Stream, as well as along some 4,000 feet of Makaleha Stream to the proposed water development site. A flora survey report documenting field observations was subsequently made by Char & Associates and is incorporated within the EIS.

A survey of the faunal resources in Makaleha valley was made by Phillip Bruner in December, 1986 to determine which, if any, birds and feral mammals inhabit or frequent the project area. Subsequently, evaluations were made to document field survey results and to determine whether or not 1) endangered species are inhabiting or frequenting the project area; and 2) endangered species would be adversely impacted by the proposed development project. In light of comments received during public agency consultation, a later reconnaissance survey of the project site was made by Mr. Michael Kido, environmental consultant, in April, 1990 to assess whether or not an established breeding population of Koloa (Hawaiian Duck) is present within the project area.

An aquatic biological reconnaissance of Makaleha Stream was made in late 1986 to identify the composition and abundance of macrofauna in Makaleha stream. The initial reconnaissance study was expanded in April, 1990 to address the concerns raised by the State Office of Environmental Quality Control. The April, 1990 study gave greater attention to the physiochemical conditions of existing biota and the impact of changes in stream flow conditions.

1.3 AGENCY AND PUBLIC CONSULTATION

Consultation with representatives of various private and public agencies was made during preparation of the draft EIS. The agency representatives consulted, their related affiliation, and their provision of written or verbal information are summarized in Table 1-1. Documented information obtained from these agencies is presented in Appendix A.

Following preparation and circulation of the draft EIS, several public agencies in Hawaii provided documented comments concerning the proposed project. These comments and the related responses from Portugal & Associates, Inc., are presented in Appendix B.

1.4 RESPONSIBILITY FOR EIS PREPARATION

This environmental impact statement was prepared by Portugal and Associates, Inc., consulting engineers and land surveyors. The firm was retained by the State of Hawaii, Department of Land and Natural Resources, Division of Water Resource Management, to prepare engineering design plans, and related design specifications, for the construction of the Upper Makaleha Springs Water Source Development Project.

TABLE 1-1

SUMMARY OF CONSULTATION WITH SELECTED PUBLIC AND PRIVATE AGENCIES

Agency	Representative	Type of Response
United States Government		
Soil Conservation Service	Laurie K. Ho	written
Fish & Wildlife Service	Ernest Kosaka	written
Army Corps of Engineers	Everette A. Flanders	written
State of Hawaii		
Dept. of Health	Theodore Inouye	written
Division of Forestry & Wildlife	Ralph E. Daehler	written
Division of State Parks	Ralston H. Nagata	written
County of Kauai		
Department of Planning	Avery H. Youn	written
Department of Water	Raymond H. Sato	verbal
Private & Community Organizations		
Lihue Plantation Company	Lefty H. Kawazoe	written
Office of Hawaiian Affairs	Earl Neller	written
Kauai Outdoor Circle	Nina Magoun	verbal
Kauai Sierra Club	Bert Lyon	none
Kauai Audubon Society	David Boynton	none
Conservation Council for Hawaii	Mike Kido	none

CHAPTER TWO

PROJECT ALTERNATIVES

CHAPTER TWO
PROJECT ALTERNATIVES

2.1 SIGNIFICANT FACTORS INFLUENCING WATER RESOURCE DEVELOPMENT

2.1.1 Existing Potable Water Demands

The Kapaa-Wailua water system presently serves approximately 4,460 metered consumers (Yamase, 1990). During FY 1989, potable water consumption in the Kapaa-Wailua area was slightly more than one billion gallons, or about 25 percent of the Kauai's total consumption (Kauai Office of Economic Development, 1989). Average daily demand for the Kapaa-Wailua water system is roughly 2.79 million gallons per day (Yamase, 1990).

Unfortunately, water consumption in the Kapaa-Wailua area has severely strained and/or exceeded available water supply since 1982. The 1.0 mgd storage tank serving the upper Kapaa Homesteads, for example, has been depleted of its supply on several occasions during the past five years. The lack of available supply has prompted Kauai County officials to impose 1) a moratorium on the development of residential subdivisions containing more than 15 lots; 2) voluntary water use restrictions, during the summer months, by larger agricultural consumers; and 3) occasional voluntary water use restrictions upon other domestic and commercial consumers.

Development of the existing Makaleha well, completed in FY 1988, has provided some temporary relief to local water shortage problems. The development permitted Kauai County officials to lift its former moratorium on the development of residential subdivisions containing more than 15 residential lots. In addition, it allowed the County to approve development of some 500 additional residential units in the Kapaa-Wailua service area. Despite the presence of additional potable water supply, County Department of Water representatives continue to view the Kapaa-Wailua system as deficient in light of present consumption and growing pressures for land development. A number of land use development projects have already been curtailed because of the lack of any additional water supply in the Kapaa-Wailua system (Fujikawa, 1990).

2.1.2 Future Potable Water Demands in the Kapaa-Wailua Area

The Kauai Water Use and Development Plan, published by R.M. Towill Corporation in 1990, indicates that present flows will increase to 2.65 mgd by the year 2010. As stated earlier, more recent estimates of consumption for the FY 1989 period indicate that existing consumption (2.79 mgd) has already surpassed Towill's potable water demand estimate for the year 2010. A more useful forecast, provided in the Towill plan, relates to the potential urbanization of the Kapaa-Wailua area during the next 20 years. The Towill forecast suggests that the average daily demand in the Kapaa-Wailua area will increase to roughly 5.63 mgd if 1) the Kapaa-Wailua area is developed as outlined in the Kauai County General Plan and existing zoning densities; and 2) the resident population increases to the levels predicted by the State Department of Business and Economic Development.

2.2 METHOD OF ALTERNATIVE EVALUATION AND COMPARISON

Three project alternatives are presented in Sections 2.3 through 2.5. Each alternative is identified in terms of general scope, location, and significant project consequences. Subsequently, each development option is further evaluated on a comparative basis.

Arbitrary statistical ratings and related comparisons were made to better assess the desirability and undesirability of those potential impacts which 1) may be significant, and/or 2) are of concern to public agencies consulted during preparation of the environmental impact statement. Project evaluation criteria used for the comparison of alternatives included a combination of both short-term, long-term, and cumulative impacts. Those issues considered in the evaluation included the following:

Conserves aquatic resources of Makaleha and Kapaa Streams;
Conserves surface water quality of Makaleha and Kapaa Streams;
Increases available potable water supply for Wailua-Kapaa service area;
Conserves the wildlife habitat of the Makaleha and Kapaa watersheds; and
Maintains the surface water supply for Lihue Plantation Company.

The statistical rating of alternatives was made by assigning weighted values to each of the evaluation criteria and subsequently rating the potential impact of each alternative on each of the established evaluation criteria.

Weighted values, assigned to each evaluation criteria, ranged from 0.1 to 1.0. Higher weighted values indicated issues believed to be of greater importance to public agencies and the general public. The rating of individual criteria for each alternative involved the determination of numerical scores ranging from 1 to 10. Lower scores, e.g. 0 to 3, indicated a potential adverse impact which is not expected to benefit the community or the local resource affected. A score of 5 or 6 suggests that the implementation of the given alternative will not influence, or adversely affect, the criteria/resource being considered. Scores ranging from 7 to 10 represent potential impacts which are expected to benefit the community and/or the local resource in question. The alternative receiving the highest cumulative score represents the most desirable overall alternative.

While subjective and arbitrary, this analytical method, combined with other analyses made in Chapter Two, is useful for alternative comparison. This approach provides the reviewer with the information necessary to identify and evaluate the rationale used for alternative selection.

2.3 PROJECT ALTERNATIVE A: THE NO PROJECT OPTION

Under Alternative A, no project would be undertaken to provide additional water supply for the Kapaa-Wailua area. Continued water conservation efforts would be encouraged and carried out by the Kauai County Water Department to sustain existing land use development and support the existing resident and visitor population. The development of vacant property and/or the rezoning of developed lands to higher densities would not be permitted due to the unavailability of additional water supply.

2.4 PROJECT ALTERNATIVE B: DRILL A NEW WELL AT AKULIKULI RIDGE

This development option would involve the drilling of a groundwater well in the ridge next to the existing Akulikuli tunnel (Figure 2-1), at approximately 360 feet above mean sea level (MSL). This well location would "*....provide access to the aquifers within the Waimea volcanic series at a minimum lift*" (Island Resources, 1981).

Installation of a water transmission pipe from the tunnel to the County's water storage tank would also be required.

2.5 PROJECT ALTERNATIVE C: ENLARGE EXISTING TUNNELS

The Moelepe, Makaleha, and Akulikuli tunnels (Figure 2-1) presently supply roughly 40 percent of the potable water consumed in the Kapaa-Wailua service area.

"*Small additional quantities of perched groundwater might be diverted into Moelepe and Makaleha tunnels by drilling small diameter holes (5 to 10 feet in length) into the ceilings at selected locations*" (Island Resources, 1981).

Existing intakes and pipe from the Moelepe, Makaleha and Akulikuli tunnels already discharge water from these tunnels to Makaleha or Kapaa Stream.

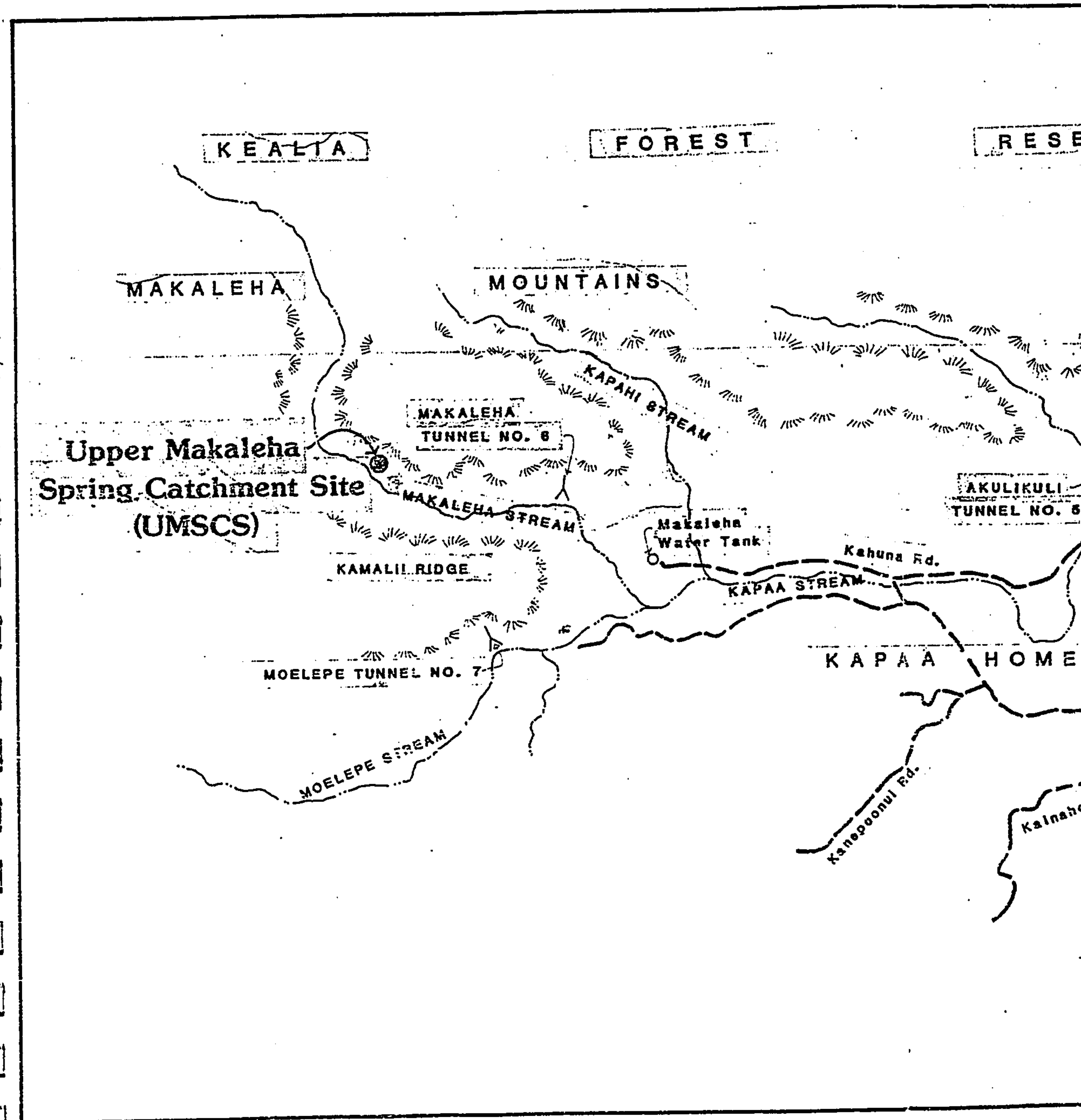
2.6 PROJECT ALTERNATIVE D: IMPOUNDMENT OF A SURFACE WATER SUPPLY

This alternate development approach would involve the development of a surface supply at some location in the upper Kapaa Homestead area. This alternative would require the construction of, at least, a one-acre surface impoundment in the vicinity of the County water storage tank along Kapaa Stream (Figure 2-1). The depth of the tank would be approximately 10 feet.

Related facility development would include the construction of a related water treatment facility and the installation of a water transmission line from the surface impoundment to the County storage tank. Two water pumps may also be required; however, this requirement is dependent upon the selected location of the impoundment, as well as the elevation difference between the County storage tank and the water treatment facility.

2.7 PROJECT ALTERNATIVE E: TAP NATURAL SPRINGS IN THE MAKALEHA MOUNTAINS

This project alternative would tap the natural springs in the Makaleha Mountains and transmit spring water, via gravity flow, to an existing County water storage tank in the upper Kapaa Homestead area (Figure 2-2). This option would generally involve the construction of an underground cut-off trench, a small intake structure, and an 8-inch pipe along the north side of the existing Makaleha valley. The new source would supply a flow ranging from 500 to 700 gallons per minute (gpm) to the Kapaa-Wailua water system.


KEALIA
FOREST
RESE
MAKALEHA
MOUNTAINS
KAPAHI STREAM
MAKALEHA
TUNNEL NO. 6
Upper Makaleha
Spring Catchment Site
(UMSCS)
MAKALEHA STREAM
AKULIKULI
TUNNEL NO. 5
Makaleha
Water Tank
Kahuna Rd.
KAMALII RIDGE
KAPAA STREAM
KAPAA
HOME
MOELEPE TUNNEL NO. 7
MOELEPE STREAM
Kanepoonui Rd.
Kainaho

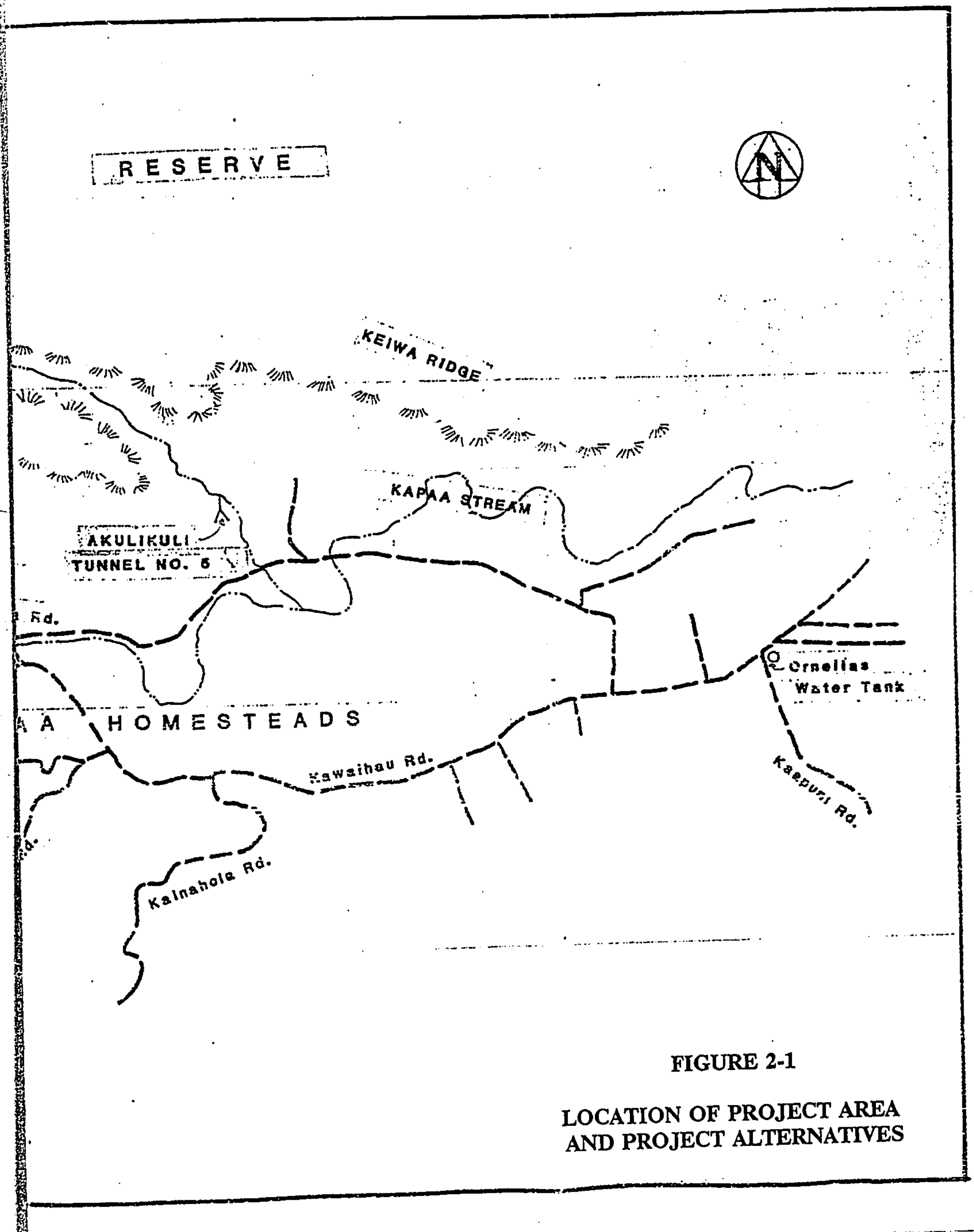
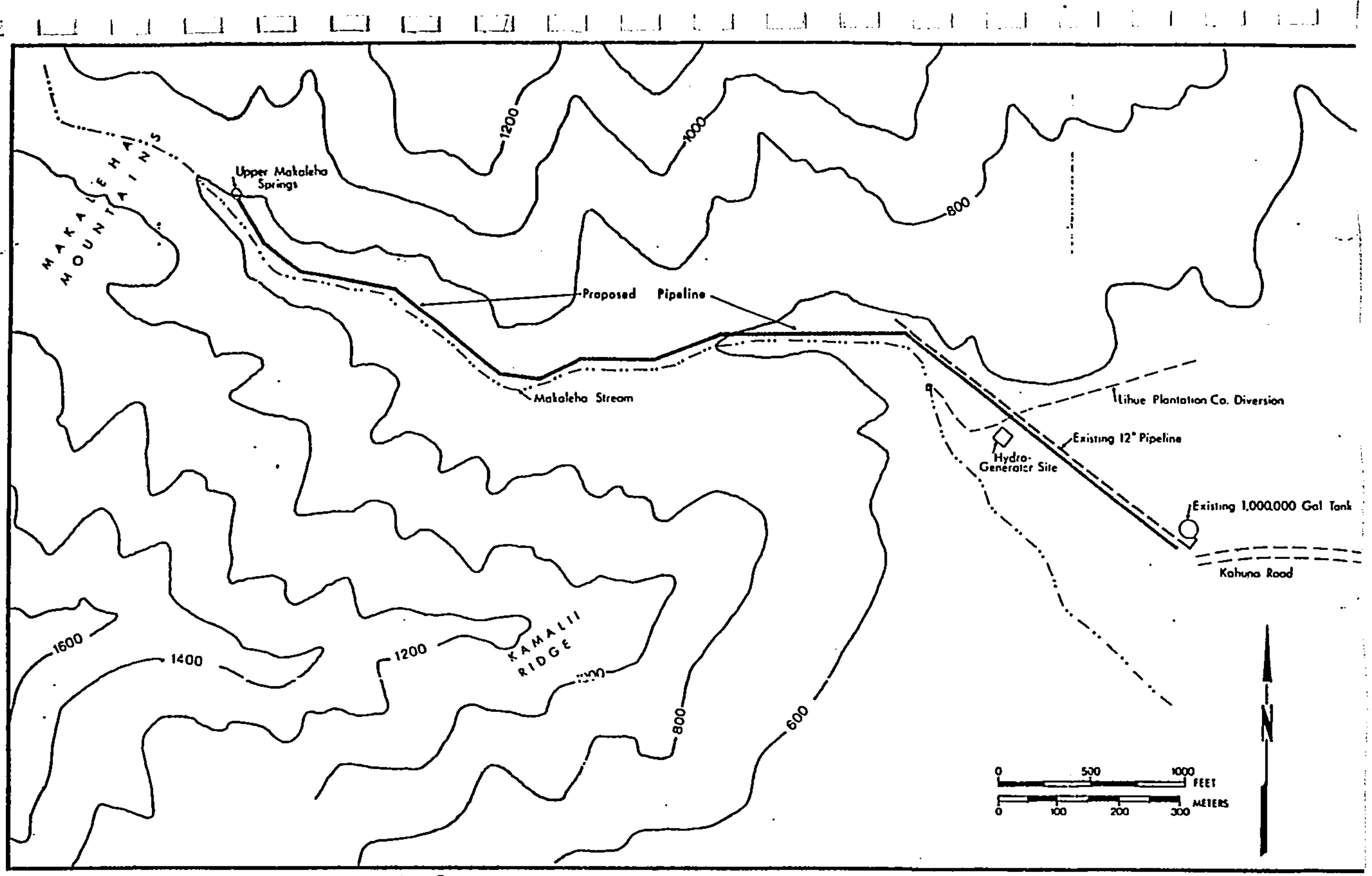


FIGURE 2-1

LOCATION OF PROJECT AREA AND PROJECT ALTERNATIVES



Map 2: Makaleha Spring Water Source Development.

FIGURE 2-2

PROJECT ALTERNATIVE E

2.8 COMPARISON OF PROJECT ALTERNATIVES

2.8.1 Conservation of Aquatic Habitat and Surface Water Quality

One of State water resource management objectives is to conserve the quality of local streams for existing and potential aquatic life. Streams located in the upper reaches of Kauai's inland watersheds generally contain little diversity, but primarily contain species endemic to the Island. For example, the primary native fish specie, found in the higher inland stream environments, are gobiids (Timbol, 1990).

In generally, native fish, crustaceans and mollusks can be influenced by significant variations in water temperature, available oxygen, and general water quality. Such variations may occur as a result of factors generating changes such as reduced stream discharges, the reduction or elimination of riparian vegetation, or the introduction of greater sedimentation.

Alternative A would have no direct impact upon local streams, e.g. Makaleha Stream, in the upper Kapaa Homestead area. Similarly, Alternative B is not expected to generate any effects upon local stream since high-level, dike-confined ground water is expected to contain little, if any, native aquatic life.

The enlargement of existing tunnels (Alternative C) represents the option having the greatest potential to generate impacts upon Makaleha and Kapaa streams. Such construction could cause increased sedimentation in Makaleha and Kapaa Streams due to the potential collapse of a portion of the existing tunnels during, or following, the enlargement of the tunnels. Pipe installations along the steep slopes of the Makaleha and Kapaa watersheds also could generate considerable sedimentation during construction without the use of practical mitigation measures.

If a suitable site could be located, development of a surface impoundment (Alternative D) would not be expected to disturb native aquatic life unless construction of the impoundment would alter local groundwater or surface flows to a nearby stream, e.g. Kapaa Stream, in the project area.

Alternative E would somewhat reduce the surface discharge of the upper Makaleha Stream. Intermittent stream measurements conducted during the past nine years indicate that Makaleha Spring contributes roughly 8 percent of the total stream discharge. The loss of discharge is not expected to have a significant effect upon native gobies because the existing stream gradient (29 percent) would help maintain adequate oxygen levels in the Stream. Limited clearing of streamside vegetation, and a 7.5 to 15 percent loss in surface discharge, may result in a slight elevation of stream temperature. Considerable sedimentation of Makaleha Stream could occur during construction without the use of practical guidelines for the construction of the proposed intake and the installation of pipe along the north side of the stream.

2.8.2 Contribution to Potable Water Demands and Related Development Costs

The no project option would not provide any additional water supply to the Kapaa-Wailua service area. As a result, this option would not incur any public funds within the short term.

Ultimately, local demands for future land use development would likely encourage the potential development of additional sources of water supply during the next decade. If this occurs, the extended delay, or future recommitment to water source development in the Makaleha area, would significantly increase the cost of such development as land values continue to soar.

The development of a well at Akulikuli Ridge is not expected to generate a significant yield as studies conducted by Island Resources "*....revealed that [a] high-level dike confined water at or near the land surface does not exist*" (Island Resources, Ltd., 1981). Project alternatives C through E which would each provide an additional supply ranging between 500 to 700 gallons per minute to the Kapaa-Wailua water system. Development costs for these alternatives would range from roughly $1.5 million for Alternatives B and E, $2.0 million for Alternative C, and roughly $3.0 million for development of a surface impoundment (Alternative D).

2.8.3 Statistical Comparison Results

The statistical rating and comparison of project alternatives (Tables 2-1 and 2-2), described in section 2.2, suggest the following preference in order of desirability:

Alternative E -	TAP NATURAL SPRINGS IN THE MAKALEHA MOUNTAINS
Alternative D -	PROJECT ALTERNATIVE D: IMPOUNDMENT OF A SURFACE WATER SUPPLY
Alternative C -	ENLARGE EXISTING TUNNELS
Alternative B -	DRILL A NEW WELL AT AKULIKULI RIDGE
Alternative A -	THE NO PROJECT OPTION

None of the alternatives are rated extremely high which points to the fact that the more pristine inland watershed environment is a challenging and difficult location to develop. Alternative E was rated the most desirable alternative because of its more cost effective development approach. Further, the proposed project is not expected to generate any significant degradation to the surface water quality, aquatic habitat, or wildlife habit in the project area. However, clearly this alternative somewhat degrades the aquatic and wildlife resources of Makaleha Stream.

Alternative D was rated second in desirability because of its non-impact upon surface water quality and aquatic life of local streams. While no specific site has been under consideration for a surface impoundment, the development of, at least, a one-acre impoundment would likely impose a significant adverse impact upon local wildlife resources with the clearing of existing vegetation.

The rating of Alternatives B and C were comparable in overall desirability. Compared to Alternatives D and E, Alternatives B and C are expected to generate more extensive degradation of surface water and aquatic habitat. However, Alternatives B and C are expected to have less impact upon local wildlife than Alternative D (Table 2-1).

TABLE 2-1

COMPARATIVE SCORING OF PROJECT ALTERNATIVES
MAKALEHA SPRINGS WATER RESOURCE DEVELOPMENT

Evaluation Criteria	Weighted Value (0.1 to 1.0)	A	B	C	D	E
1. Conserves surface water quality of Makaleha and Kapaa Streams	0.9	5	4	4	5	5
2. Conserves aquatic habitats of Makalehe and Kapaa Streams	0.9	5	4	4	5	4
3. Increases potable water supply to the Kapaa-Wailua service area.	1.0	0	5	6	6	6
4. Conserves wildlife habitat in the Makaleha and Kapaa watersheds.	0.7	5	4	4	2	4
5. Maintains the surface water supply for Lihue Plantation Co.	0.8	6	3	3	5	4
6. Represents a cost-effective development approach.	0.7	5	7	6	4	7

Note: Section 2.2 of the report summarizes the significance of weighted values and scoring ranges used in this matrix evaluation.

TABLE 2-2

COMPARISON OF FIVE PROJECT ALTERNATIVES
MAKALEHA SPRINGS WATER RESOURCE DEVELOPMENT
TOTAL WEIGHTED ALTERNATIVE SCORES

Evaluation Criteria	Weighted Value (0.1 to 1.0)	A	B	C	D	E
1. Conserves surface water quality of Makaleha and Kapaa Streams	0.9	4.5	3.6	3.6	4.5	4.5
2. Conserves aquatic habitats of Makalehe and Kapaa Streams	0.9	4.5	3.6	3.6	4.5	3.6
3. Increases potable water supply to the Kapaa-Wailua service area.	1.0	0.0	5.0	6.0	6.0	6.0
4. Conserves wildlife habitat in the Makaleha and Kapaa watersheds.	0.7	3.5	2.8	2.8	1.4	2.8
5. Maintains the surface water supply for Lihue Plantation Co.	0.8	4.8	2.4	2.4	4.0	3.2
6. Represents a cost-effective development approach.	0.7	3.5	4.9	4.2	2.8	4.9
TOTAL SCORES		20.8	22.3	22.6	23.2	25.0

Note: Total weighted score for each criteria was calculated by multiplying the comparative raw scores summarized in Table 2-1 by the weighted value for each criteria.

The "no project" option was considered to be the least desirable project alternative primarily because it does not address the increasing demand for potable water in the Kapaa-Wailua service area. Long term costs for the development of an additional water supply will be considerably higher as property values and development costs continue to rise. The only project benefit afforded by this development option is the maintenance of a continued supply to Lihue Plantation Company. Aquatic and wildlife resources would not be impacted.

2.9 PROJECT DESCRIPTION OF SELECTED PROJECT ALTERNATIVE E

2.9.1 Project Objective

The primary objective of the proposed water source development project is to expose the source of the Upper Makaleha Springs, capture the water in an underground basin, and transport the water supply to the 1.0 mgd County water storage tank at the mauka end of Kahuna Road.

2.9.2 Phase One

An underground cut-off trench (Figure 2-3) will initially be constructed at the Upper Makaleha Spring Catchment site. The trench will be long and narrow, and nestled against the base of Makaleha Valley's north wall. The size and configuration of the trench basin is somewhat dependent upon what is discovered upon exposure of the spring source. As presently designed, the intake structure will be roughly 5 feet wide, 3 feet deep, and 150 feet long.

The cut-off trench basin will be cut into the existing rock formations and constructed with a concrete rubble masonry with a reinforced concrete slab. A manhole-type structure will provide access to the cut-off trench.

Construction of the inlet will be accomplished via manual labor and some limited small equipment that will be mobilized to the project site via helicopter and/or construction laborers. Suitable rocks, excavated during the construction of the trench, will used for the concrete masonry work to eliminate the cost and impact of mobilizing fill material to the project site.

Construction of the intake structure will be scheduled during lower flow conditions, i.e., May through September, to improve work efficiency and minimize potential sedimentation to Makaleha Stream. Following construction of the intake, laborers will revegetate all exposed areas with indigenous plants.

Prior to beginning Phase Two work, a hydrogeologist will be assigned to monitor spring flows to the intake structure. Such testing will be done to verify the anticipated capture capacity of, at least, 500 gpm.

Phase One work is expected to be completed over a 4 to 9 month period. Construction work will be accomplished by a daily labor force ranging between 5 to 10 tradesmen and laborers.

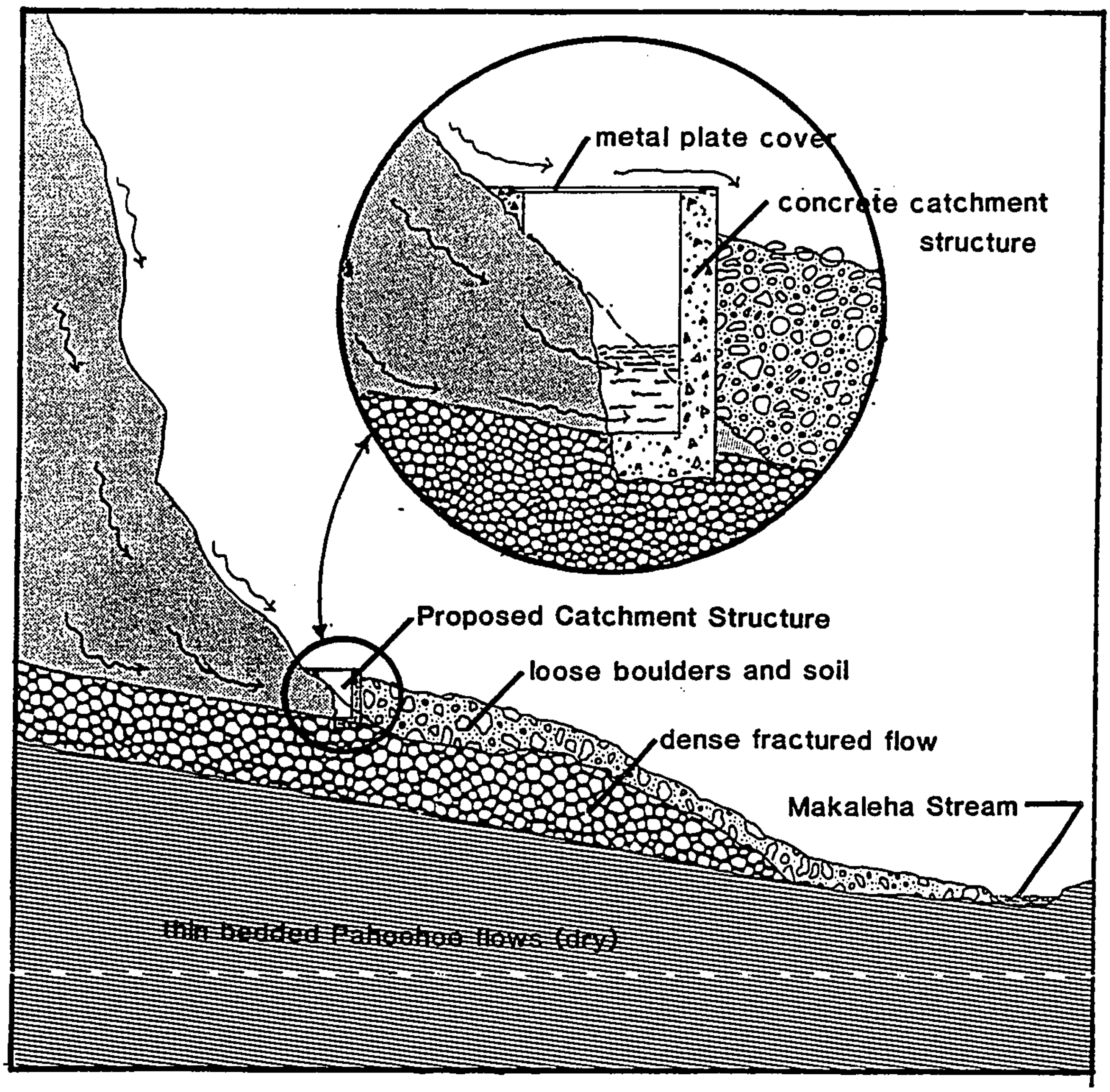


FIGURE 2-3

PROPOSED UPPER MAKALEHA SPRINGS INTAKE STRUCTURE

2.9.3 Phase Two

A valve will be installed at the outlet end of the intake device to control the amount of water entering a proposed pipeline. An 8-inch ductile iron pipeline will be built to transport water, about 4,000 feet along the north side of Makaleha valley, to the County 1.0 mgd water storage tank.

In order to reduce the visual impact of the waterline, the pipe will be installed underground in areas where practical. The rugged terrain of the valley will require that roughly half or more of the waterline will be mounted above-ground on concrete pedestals not more than three-feet above ground elevation (Figure 2-4). For example, the lowest 1,500 feet of pipeline will generally parallel the existing 12-inch diameter iron pipe that presently carries water from the existing Makaleha Tunnel to the County water storage tank.

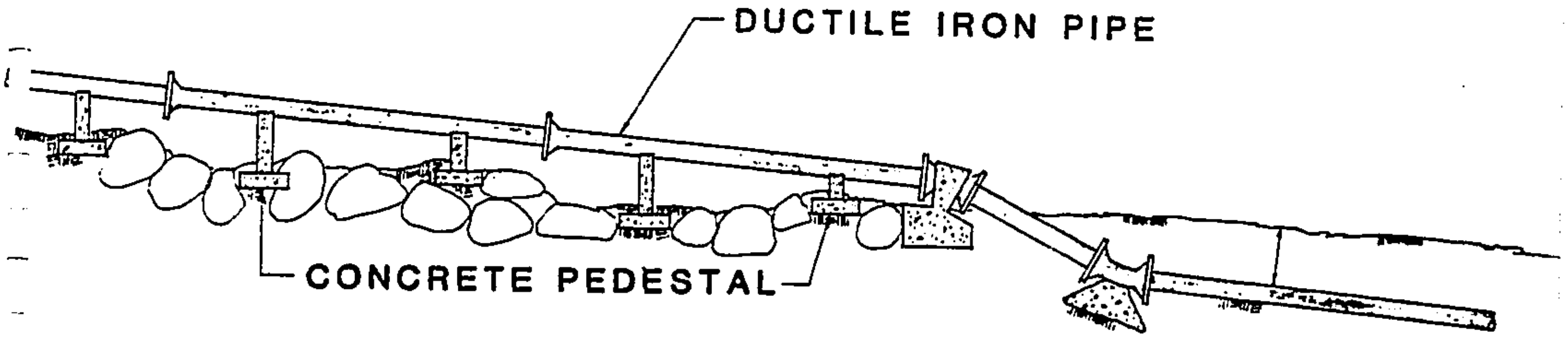
Phase Two construction of the pipeline will again be accomplished by manual labor and the related use of some smaller equipment. Suitable rock material will be used by laborers in conjunction with the construction of the concrete pedestals.

Labor crews will also establish temporary diversion swales, and make use of selected fabric material, e.g. Mirafi, to reduce the amount of potential silt-laden runoff entering Makaleha Stream. As construction of the pipeline progresses, exposed areas will be revegetated with indigenous plant species.

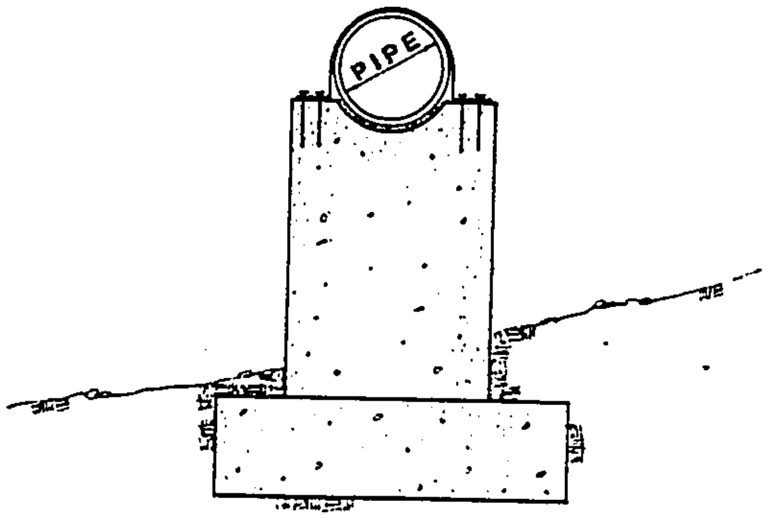
A daily labor force, consisting of 10 to 20 tradesman and laborers, will carry out the pipeline installation over a 12-month construction period.

2.9.4 Cost of Construction

The cost of constructing the entire Upper Makaleha Springs Water Resource Development Project is estimated to be $1.5 million. The planning and design of the project is being performed by the State Division of Water Resource Management. The construction of the project will be financed via a combination of State and Kauai County funds.



TYPICAL PIPE SECTION
INSTALLED ABOVE GROUND



TYPICAL CONCRETE PEDESTAL
WITH STEEL STRAPS

FIGURE 2-4

ABOVE-GROUND PIPELINE INSTALLATION
TYPICAL CONCRETE PEDESTAL FOUNDATION

CHAPTER THREE

ENVIRONMENTAL SETTING

CHAPTER THREE
ENVIRONMENTAL SETTING

3.1 PHYSICAL ENVIRONMENT

3.1.1 Project Location

The project site is situated on a 2,335-acre parcel of land owned by the State of Hawaii (TMK: 4-6-01:1). This parcel encompasses the southeast quadrant of the Makaleha Mountains and the watershed of Makaleha Stream downslope to the Lihue Plantation Company diversion dam (Figure 2-2).

3.1.2 Geology and Soils

Generalized geological maps for the project area, as well as general onsite observations, indicate that the upper slopes of Makaleha valley are characterized by highly weathered lavas of the Waimea volcanic series known as the Napili Formation (MacDonald and Abbott, 1970).

The base, and possibly the lower slopes, of the valley are believed to be dominated by rock from the Koloa series. Rock from the Koloa series is younger than the rock of the weathered lavas of the Waimea volcanic series. The structure of the rock is considerably more complex because of its variable composition of basalts, cinder ash bed layers that are frequently interspersed with permeable and fractured gravel materials.

Soils such as Kolokolo extremely stony clay loam and Kapaa silty clay overlay the rock of the Koloa series (U.S. Soil Conservation Service, 1972).

3.1.3 Climate

The climate of east Kauai is generally warm throughout the year with ambient temperatures ranging from 70 to almost 80 degrees Fahrenheit.

While temperatures are generally consistent throughout the year, rainfall (Table 3-1) and surface wind characteristics in the Kapaa-Wailua area suggest a 5-month "summer" season and a 7-month "winter" season. The summer season, from May through September, is a higher sun period that is characterized by both warmer temperatures and more steady tradewind conditions. In contrast, the winter season typically includes somewhat cooler temperatures, greater storm-generated rainfall, and less frequent tradewinds (Giambelluca, Nullet, and Schroeder, 1986).

The headwaters of Makaleha Stream area situated at elevations considerably higher where existing rainfall records are available. General rainfall distribution information for the Island of Kauai indicates that the project area receives between 150-200 inches of rainfall per year (Figure 3-1). With the exception of the amount of rainfall, it is believed that seasonal precipitation patterns, at lower elevations, are consistent with rainfall occurrence at higher elevations.

TABLE 3-1

SEASONAL MEDIAN RAINFALL CHARACTERISTICS
KAPAA-WAILUA SERVICE AREA
(MILLIMETERS)

January	150
February	100
March	100
April	100
May	75
June	50
July	75
August	50
September	50
October	100
November	150
December	150

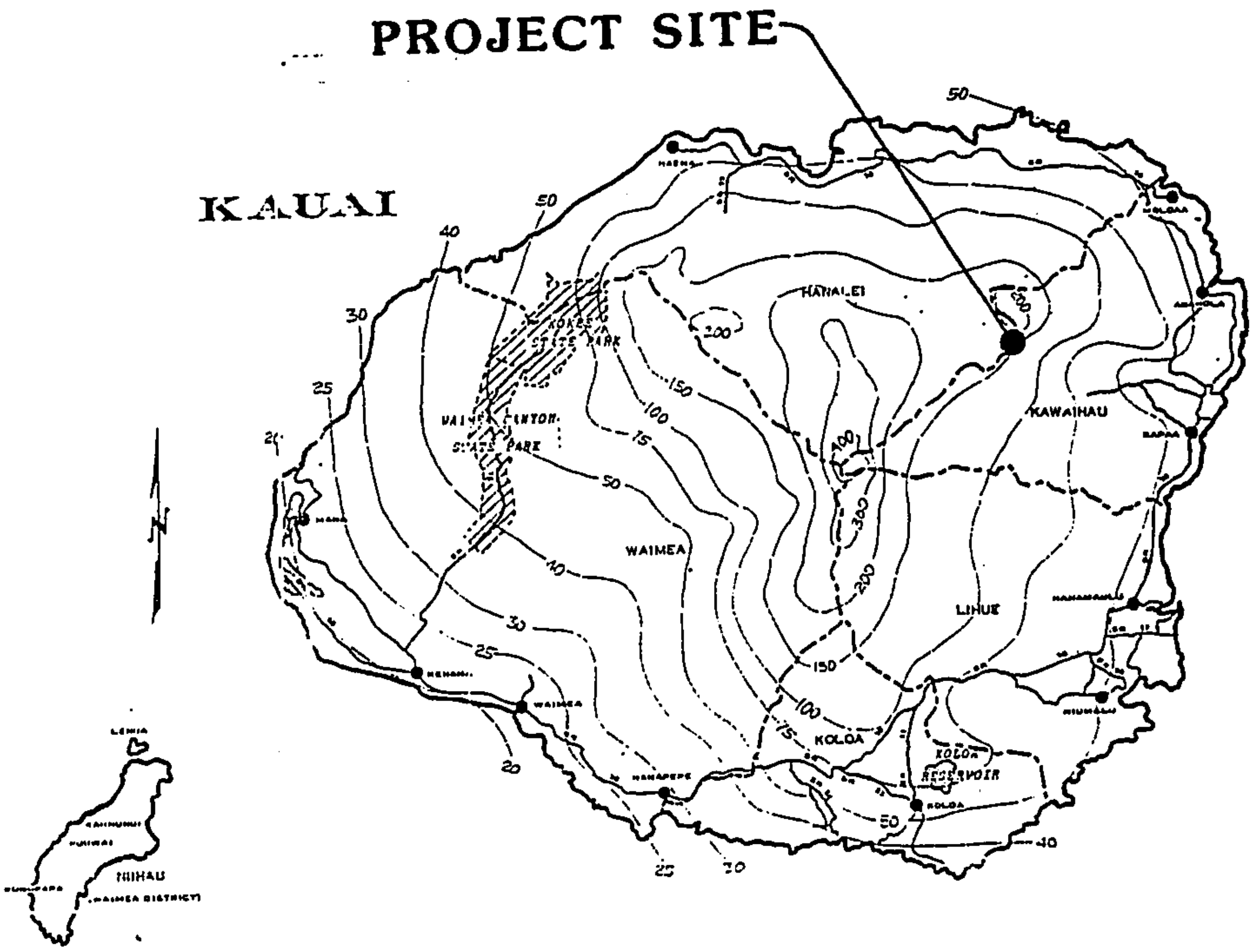


FIGURE 3-1

ANNUAL RAINFALL DISTRIBUTION
ISLAND OF KAUAI

3.1.4 Topography

Makaleha Valley is a steep-sloped drainage area about 2.4 miles long. The headwaters of the valley begin at about 1,800 feet above mean sea level (MSL). Downstream of the headwaters, the Upper Makaleha Springs area is situated at about 800 feet above mean sea level (Figure 2-2). Elevations within the valley's descend at an average slope of 14 percent between the valley headwaters and the confluence of Makaleha and Kapaa Streams. The County's 1.0 mgd storage tank, situated near the confluence of Makaleha and Kapaa Streams, is located at about the 440-foot elevation.

In the vicinity of Makaleha Springs, Makaleha valley becomes relatively narrow with the width ranging from 5 to 10 feet; stream width generally increases downstream with the maximum width being 25 feet under medium flow conditions. Field observations, under variable flow conditions, indicate that the width, depth and velocity of the Stream doubles during high flow conditions.

The Valley floor is very rocky with large boulders, some in excess of ten feet in diameter. The boulders are especially evident in the stream bed area.

3.1.5 Hydrology

Percolating rainfall is perched by dense lava characterizing the steep slopes of Makaleha Valley (Figure 3-2). The Upper Makaleha Springs emerge where steeper sloping rock boulders begin to thin out. Upon discharge, the water flows along defined channels which empty in Makaleha Stream (Figure 3-3). A review of streamflow records from the U.S. Geological Survey gaging station indicates the average annual streamflow is approximately 6.8 cubic feet per second, or a flow of roughly 3,060 gallons per minute (gpm).

Lihue Plantation Company, Ltd. (LPC) is presently diverting streamflows ranging from 4.7 to 9.5 mgd from Makaleha Stream at a point approximately 400 feet downstream Makaleha Tunnel No. 6 (Figure 2-1). As expected, Lihue Plantation records indicate that the volume of diversion is less during drier summer flows and increases during the wetter months characterized by higher streamflows (Ishimoto, 1988). The diverted water is used to irrigate sugarcane fields in the nearby Kealia area.

The State of Hawaii has advised Lihue Plantation Company, Ltd. of its intention to use a portion of the Makaleha Stream flows as a domestic supply for the Kapaa-Wailua area. LPC presently is holding a lease for the land parcel containing the Makaleha Spring and Stream area. The terms and conditions of its existing lease (GL S-3827), which expires on May 10, 1994, stipulate that the State of Hawaii has the right to divert 1.0 mgd from the Stream provided that its lessee (LPC) receives not less than two years advance notice.

Field observations made in March-April, 1990 indicate that water emerging from Makaleha Springs contributes roughly 8 to 15 percent of Makaleha Stream's total flow. Various observations and estimates the Makaleha Spring discharge have been made since 1981; these estimates are summarized in Table 3-2.

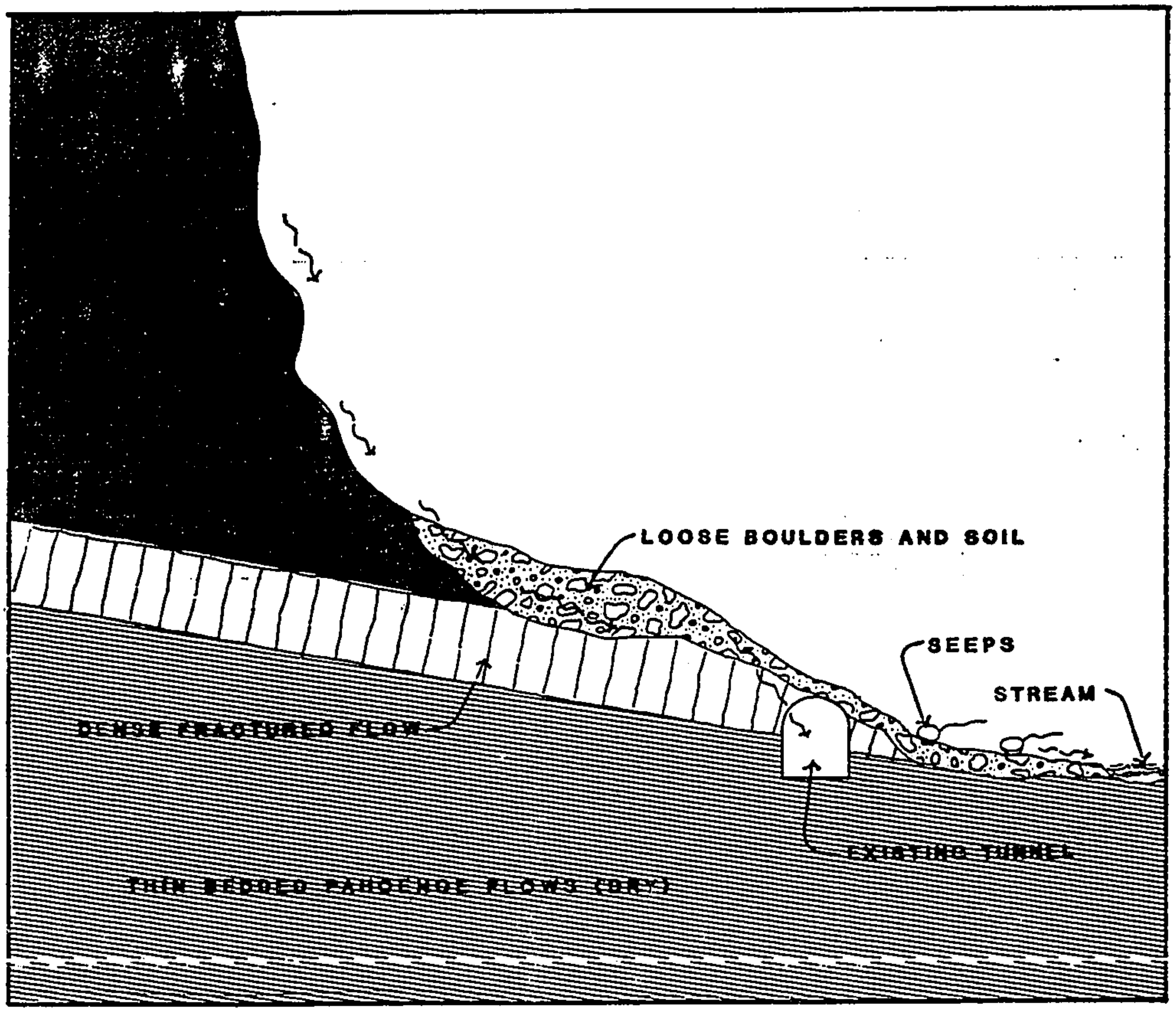


FIGURE 3-2

TYPICAL PERCHED GROUNDWATER OCCURRENCE AT MOELEPE TUNNEL, MAKALEHA TUNNEL, AND UPPER MAKALEHA SPRINGS
(not to scale)

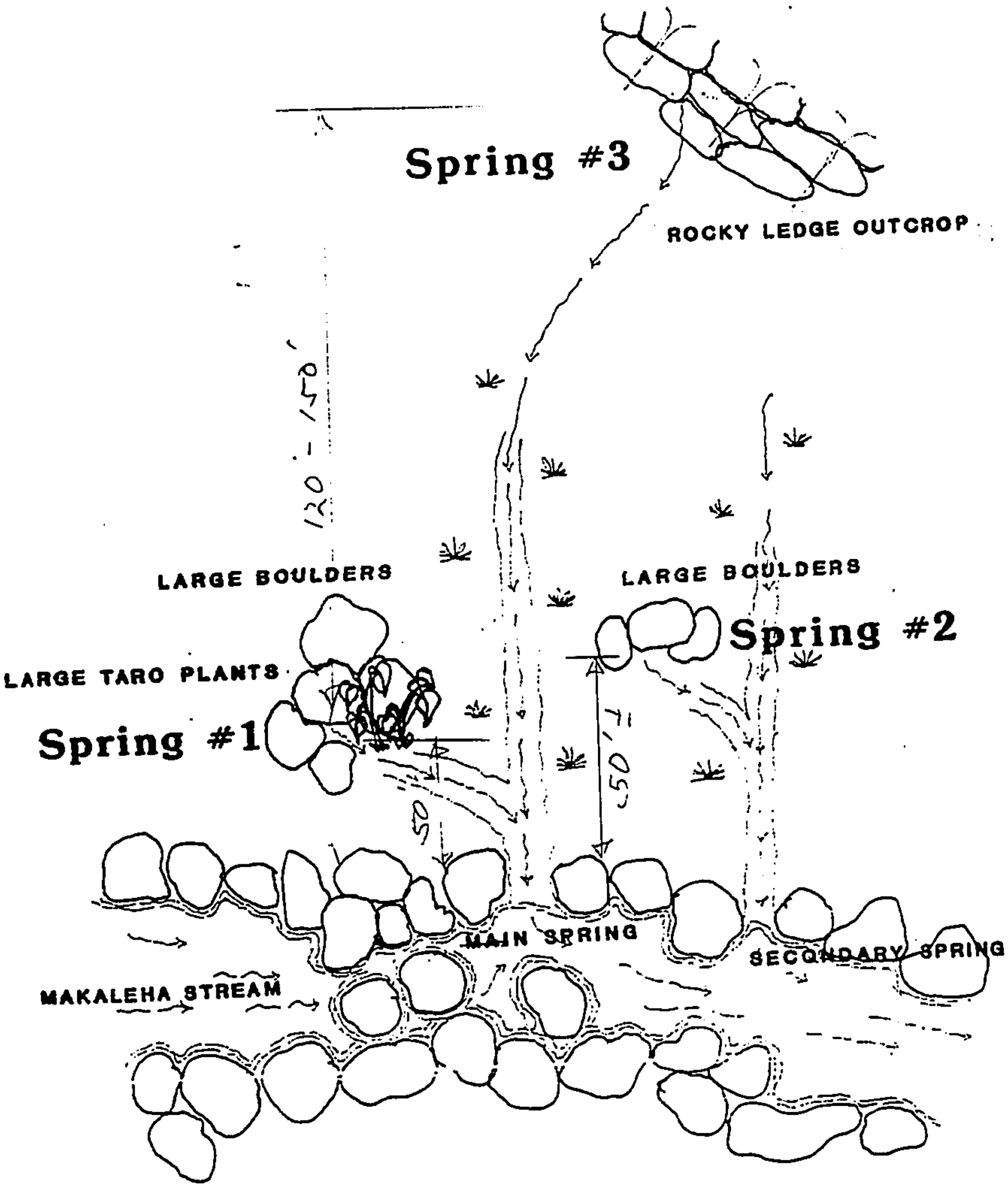


FIGURE 3-3

SKETCH OF UPPER MAKALEHA SPRINGS
(not to scale)

TABLE 3-2

SUMMARY OF SPRING DISCHARGE OBSERVATIONS
MAKALEHA SPRINGS
1981 - 1990

Observation Period	Estimated Spring Discharge (gpm)	Method of Measurement	Observer(s)
June 25-26, 1981	500	visual	Bowles
May 18, 1984	1,500	rough cross section critical depth method	Fujikawa
July 13, 1984	430	3-inch Parshall flume	Kojiri
December 6, 1986	1,070	Pygmy Propeller & Parshall Flume	Mills
March 29-30, 1990	709	Reid equation & Swoffer flow meter	Timbol

Sources: Bowles, 1981; Portugal & Associates, 1987; and Timbol, 1990.

3.2 BIOLOGICAL RESOURCES

3.2.1 Aquatic Resources of Makaleha Stream

The aquatic resources of Makaleha Stream were surveyed by Amadeo Timbol, Ph.D, aquatic biologist, in August, 1986 and March-April, 1990. Analyses made in conjunction with this fieldwork are summarized in Appendix C.

Fauna that has been observed in Makaleha Stream contains little diversity in composition, but most species are endemic to Hawaiian aquatic environments. In the upper reaches of the Stream, gobiids are the predominant native fish.

"***All the native fishes that are restricted to fresh water as adults are diadromous....Adult gobies spawn over a period of months in freshwater, mostly in the lower reaches of streams. Hatchlings are carried out to sea by stream current where they spend a marine existence as plankton. These then metamorphose into post-larvae (hinana) near the mouths of streams, settle on appropriate substrata, and migrate upstream to their places of permanent residences***" (Timbol, 1990).

In addition to native fish, field surveys also reported the presence of 8 insects, one crustacea, one amphibia, and one annelida. Of the fourteen species observed in the Stream, 11 species are endemic to Hawaii.

3.2.2 Vegetation

A botanical survey was made along Kapaa Road from the County water storage tank to the confluence of Makaleha and Kapaa Streams, as well as along the stream banks of Makaleha to the Makaleha Springs site. This survey was conducted in December, 1986 by George Linney and Winona Char of Char & Associates. Appendix D presents a summary of field results and an assessment of the proposed project upon the floral resources of the project area.

The field survey reported a total of 123 plant species which included 26 ferns and 97 flowering plants. These plants were located in three general types of habitats: open field, stream banks, and closed forest.

Most of the species identified are exotic. None of the plants reported included species that have been identified or proposed by federal or State agencies for "rare", "threatened" or "endangered" status.

3.2.3 Wildlife Resources

The wildlife resources of Makaleha valley were observed during a one-day survey of Makaleha Valley on December 23, 1986 by Phil Bruner, wildlife biology consultant. This survey was supplemented by a second bird survey in March-April, 1990 that was performed by Michael Kido, environmental consultant. The second survey consisted of 12 different observation periods that focused solely upon the sighting and evaluation of Koloa, the Hawaiian duck, and its potential habitat. Analyses made in conjunction with both surveys are presented in Appendix E.

Wildlife in Makaleha Valley consists of, at least, feral pigs and dogs, as well as various species of exotic and native birds. Resident birds included the White-tailed Tropicbird, 'Amakihi, and the Hawaiian Duck. A total of six exotic birds were also observed; the Japanese White-eye was the most common bird sighted during related field surveys.

Analyses made by Michael Kido conclude that the Koloa is probably not a permanent resident of Makaleha Valley even though potential habitat is present in the upper portions of the valley. The dense growth of hau has formed a low, closed canopy of vegetation which is believed to be unattractive to the lower-flying Koloa. In addition, increased human disturbance by hikers and hunters also presents another factor that reduces the suitability of Makaleha Stream for the Koloa (Kido, 1990).

3.3 CULTURAL RESOURCES

3.3.1 Archaeological Resources

An archaeological reconnaissance was made of the Makaleha Stream area by Hallett Hammatt, Ph.D., of Cultural Surveys Hawaii on October 1, 1986. The results of this reconnaissance are summarized in Appendix F.

Selected valley slope areas were examined during the survey to locate potential terracing areas and other archaeological features. However, no features were discovered. The Cultural Surveys Hawaii archaeologist concluded that the valley slopes are too steep and narrow to practically support the development of agricultural terracing. Further, any other past features have clearly been destroyed during past higher flow stream conditions.

3.3.2 Population and General Land Development Trends

3.3.2.1 Island of Kauai

During the past two decades, the Island of Kauai has emerged from a sugar cane plantation community of roughly 29,800 residents to a community of approximately 51,000 persons in July, 1989 (State Department of Business and Economic Development, 1990) that is principally based upon the visitor industry. The shift in emphasis from sugar production to the visitor industry was marked by the gradual increase in visitor arrivals that grew from roughly 410,000 visitors in 1970 to 1,177,000 visitors in 1989 (State Department of Business and Economic Development, 1982 and 1989). This increase in visitor arrivals represents an average annual growth rate of 10 percent since 1970.

The growth of the visitor industry during the past decades has fueled additional private investments and the related construction of hotels, resort condominiums, commercial retail centers, as well as residential apartments and single family residential subdivisions. By the year 2000, it is estimated that an additional 2,634 hotel, condominium, and apartment units (available as visitor accommodations) will be constructed on Kauai to supplement an existing inventory of 7,563 hotel, condominium, apartment-hotel, and cottage units (Kauai County Office of Economic Development, 1989). Roughly one-third of this development is expected to occur in the Wailua-Kapaa area.

The continued growth of the visitor industry and related secondary services in the local Kauai economy is expected to sustain continued growth in resident and visitor populations. The State Department of Business and Economic Development estimates that Kauai's future resident population will increase to roughly 61,100 persons in 1995 and approximately 68,200 persons by the year 2000. Westbound visitor arrivals during the same period are expected to increase to almost 1,473,000 in 1995 and to approximately 1,657,000 in 1998 (Kauai County Office of Economic Development, 1989).

3.3.2.2 Kapaa-Wailua Area

Kauai's Kapaa-Wailua area has generally paralleled the growth of the rest of the island during the past 20 years. The Kapaa-Wailua area is part of the larger Kawaihau district which includes the residential communities of Wailua, Waipouli, Kapaa, and Anahola. Since 1980, the Kawaihau district has grown at the rate of roughly 3.8 percent per year, or almost double the average population growth rate of most American communities. In 1970, the resident population of Kawaihau district included 5,173 persons. By 1980, the district population increased to 5,846 residents. More recent estimates for the Kawaihau district indicate a resident population of roughly 13,700 persons in 1988 (Kauai County Office of Economic Development, 1989). The present resident population of the somewhat smaller Kapaa-Wailua area is believed to be about 12,500 persons.

Approximately 2,800 hotel, condominium, and apartment-hotel units are situated in the Kapaa-Wailua area. By the year 2000, the existing number of hotel, condominium, and apartment-hotel units in this area is expected to be approximately 3,723 units (Kauai County Office of Economic Development, 1989). Consequently, the Kapaa-Wailua area will continue to be Kauai's primary location for visitor accommodations.

3.3.3 Recreation in the Makaleha Springs Area

Recreation occurring with the Makaleha Springs area include some limited fresh-water fishing, pig hunting, and hiking.

3.4 BUILT ENVIRONMENT

3.4.1 Existing Water System Serving the Kapaa-Wailua Area

3.4.1.1 Location and Size

The Kapaa-Wailua Water System is the largest water system on the Island of Kauai. As stated earlier, the average daily demand generated by this service area is already 2.79 mgd.

The Kapaa-Wailua water system service area extends from Kauai Hilton and Beach Villas to Kealia and encompasses Wailua Homesteads, Wailua Houselots, Kapaa Town and Kapaa Homesteads. The service area comprises three major sub-systems: Akulikuli, Moelepe, and Makaleha.

3.4.1.2 Existing Water Sources and General Water Distribution

Akulikuli Tunnel 5, Moelepe Tunnel 7 and Makaleha Tunnel (Figure 2-1) are the existing water sources serving the three respective sub-systems. Water is distributed initially to the higher elevation areas and subsequently distributed to lower elevation customers via a series of storage tanks and pressure-reducing facilities.

Water obtained from the Moelepe Tunnel is presently diverted to the Wailua Homesteads area and booster pumped to the Puu Pilo storage tank. The Makaleha and Akulikuli tunnels supply the Kapaa Homesteads and Kapaa Town. The Wailua Houselots and Wailua Town areas are served by basal ground water obtained from deep well pumps located on the eastern slopes of the Nonou Mountain Range.

3.4.1.3 Makaleha Sub-System

The water supply from Makaleha tunnel, the source of supply for this sub-system, is stored in the 1.0 mgd County water storage tank at the end of Kahuna Road. A 12-inch cast iron transmission line connects the storage facility to its source. Distribution is made through a combination of 8-inch, 10-inch, and 12-inch mains along Kawaihau Road to service Kauai County's customers in Kapahi, Kawaihau, and the upper portions of Kaapuni Road.

The Makaleha sub-system is inter-connected to the Akulikuli sub-system and can assist in replenishing the supply in the 0.2 million gallon Ornellas storage tank (Figure 2-1) at the Kawaihau-Kaapuni intersection. The Makaleha sub-system is also inter-connected to the Moelepe sub-system through a six-inch cast iron main along Kanepoonui Road. While the latter inter-connection provides the County of Kauai with the capability to transfer water betweem the Makaleha and Moelepe sub-systems, this interconnection is left closed under normal operating conditions.

Presently, the combined 1.5 mgd capacity of the Makaleha and Akulikuli tunnels represents the Kapaa area's primary source of potable water. Unfortunately, present average day demands have been estimated to be 2.79 mgd. For this reason, the Nonou wells, which are also operating at capacity, are temporarily being used to supplement Kapaa's maximum day demands until additional water sources can be developed. Consequently, the development of additional source(s) of water is a primary concern of the Kauai County Department of Water (Fujikawa, 1990).

3.5 PLANS, POLICIES AND CONTROLS

3.5.1 Kealia Forest Reserve

Makaleha Springs and Stream are situated with the Kealia Forest Reserve. The Reserve was established in 1906 to conserve the watershed of Makaleha Mountains for water supply purposes. Under General Lease S-3827, East Kauai Water Company (Lihue Plantation Company) continues the long-standing practice of diverting surface runoff from the Makaleha Mountains to irrigate sugarcane fields. The lease reserves the right for the State of Hawaii to withdraw water from the lease area for domestic purposes. Consequently, the proposal to develop additional domestic water supply is consistent with the purpose of the Kealia Forest Reserve.

A related objective of the Reserve is to conserve the natural environment of the mountains for recreational fishing and hunting, as well as wildlife enhancement.

3.5.2 Hawaii State Plan, Hawaii Revised Statutes, Chapter 226

The Hawaii State Plan provides a guide for the short and long-term development of Hawaii. These guidelines are presented in the context of regional goals, objectives, policies, and priorities concerning Hawaii's population, economy, environment, and man-made resources (Office of the Governor, Office of State Planning, 1988). In the following paragraphs, the guidelines considered relevant to the Upper Makaleha Springs Water Resource Development Project are identified.

Physical Environment - Land-based, Shoreline, and Marine Resources: Section 226-11

The primary focus of the objectives outlined in Section 226-11 is to bring a balance between land-based or water-based activities and natural resources. The planning phase of project development is emphasized in these objectives. Planning with watershed areas should include consideration of multiple uses, provided that such uses do not adversely affect water quality and groundwater recharge.

Facility Systems - Water: Section 226-16

The objectives and policies in Section 226-16 are directed toward the State's intention to provide adequate water supplies that support domestic, agricultural, commercial, industrial, recreational, and other community needs within the capacity of existing resources. A recommended approach for developing water supply systems and facilities is also addressed. This section outlines policies which include 1) developing adequate water supplies in advance of anticipated needs; 2) supporting water supply services to areas experiencing critical water problems; and 3) coordinating water development efforts with anticipated land use activities.

3.5.3 State Land Use Designations

The Makaleha Springs and Stream area is situated with an area designated for "conservation" uses. Lands designated for conservation use are administered by the State Department of Land and Natural Resources.

3.5.4 Hawaii Coastal Zone Management Act, Chapter 205A, Hawaii Revised Statutes

Chapter 205A outlines, in part, the State of Hawaii's coastal zone management objectives, policies and guidelines. While the project area has not been designated as a special management area by the Kauai County Planning Commission, the broadly written State law has resulted in a CZM review of all lands in the State except forest reserves and federal land. The project area is situated in the Kealia Forest Reserve.

Despite the question in applicability of this statute to the proposed project, a review of the State CZM objectives policies and guidelines indicates that the only relevant objectives concern scenic and open space resources. The general intention of the State for these resources is the general objective of encouraging non-coastal dependent activities to inland areas of the island.

3.5.5 State Department of Health

Chapter 20, Title 11, Section 11-20-29, of the State Administrative Rules, requires the State Department of Health to approve all new water sources that serve public water systems. Such approval is based upon the submission of an engineering report that satisfactorily addresses all of the issues identified in the State administrative rules. Consultation with State Department of Health representatives indicate that such issues include, at least, the following:

1. Nature of the soil and substrata overlaying the water source;
2. Nature, distance, direction of flow and time of travel of contaminants from present and anticipated domestic, industrial, and agricultural sources of pollution.
3. The probability and potential effect of surface drainage, or contaminated underground water entering the proposed water source; and
4. Water quality and flow data during variable environmental conditions (Lewin, 1990).

3.5.6 Interim Instream Flow Standard for Kauai, Chapter 13-169, Hawaii Administrative Rules

The State commission on water resource management adopted an interim instream flow standard for all streams on the Island of Kauai on June 15, 1988. This standard recognizes that stream flows vary throughout the year due to changing rainfall patters; however, the standard does not permit new or expanded diversions beyond June 15, 1988 unless there is a compelling public need.

3.5.7 Kauai County General Plan

The Kauai General Plan calls, in part, for the development of additional water sources in upper Kapaa to meet the anticipated increase in potable water demand. The development and use of Upper Makaleha Springs is specifically proposed to help address this issue and plan objective.

CHAPTER FOUR

ANTICIPATED ENVIRONMENTAL CONSEQUENCES
AND
PROPOSED
MITIGATIVE MEASURES

CHAPTER FOUR
ANTICIPATED ENVIRONMENTAL CONSEQUENCES AND PROPOSED MITIGATIVE MEASURES

4.1 PHYSICAL IMPACTS

4.1.1 Diversion of Flows from Makaleha Stream

One impact relating to diversion of flows from the Upper Makaleha Springs would be a reduction in supply to Lihue Plantation Company. Representatives of LPC indicate that 1,000 acres of sugarcane in the Kealia area are presently being irrigated by LPC's diversion of Makaleha Stream flows that range from 4.7 to 9.5 mgd, or a flow of 3,265 to 6,600 gallons per minute (gpm). The proposed diversion of roughly 500 gpm for domestic supply purposes would reduce Lihue Plantation's irrigated flow approximately 7.5 percent during the wetter months of October through April. The impact upon the LPC's diverted irrigation supply would increase to a 15 percent diversion in the drier months of May through September.

The extent of this impact upon sugarcane production is not known because the irrigation of fields in the Kealia area relies upon a complex series of surface and groundwater sources and related distribution. During consultation with Lihue Plantation, LPC representatives were unable to quantify the potential impact of the anticipated diversion upon sugar cane production. However, a simplified evaluation of the sugarcane production suggests that diversion of 7.5 to 15 percent of available water supply could, in the worst case, eliminate production on 75 to 150 acres of existing sugarcane land.

While the impact presents an adverse consequence to Lihue Plantation Company, it should be noted that one primary purpose of the Kealia Forest Reserve is to conserve water resources for the general public. Greater use of greater drip irrigation and other agricultural water conservation efforts by Lihue Plantation could possibly mitigate this impact.

4.1.2 Temporary Sedimentation of Makaleha Stream

Construction of the proposed intake structure, installation of the 8-inch transmission line, and increased foot traffic in Makaleha Valley will generate some temporary sedimentation of the Stream. Such impacts could be significant unless proper mitigation efforts are exercised by the contractor responsible for construction. For this reason, the State of Hawaii, Division of Water Resource Management, is committed to implementing the following guidelines for construction:

1. Excavation work required to build the proposed intake structure along the north side of the valley will be scheduled and accomplished during the drier months of May through September.

2. Excavated rock and soil material (if any) will be stockpiled adjacent to the Stream prior to reuse in the construction of the intake structure or concrete pedestals. Rock material not reused will remain in riparian areas adjacent to the Stream, rather than within the active Stream waters.

3. No land-based vehicles will be permitted to operate beyond the mauka end of Kahuna Road during construction mobilization, any portion of the construction period, or final demobilization.

4. Temporary silt fences and fabric material will be used by the contractor to reduce the potential impact of sedimentation during construction of the intake structure and installation of the pipeline.

5. The contractor will temporarily halt construction efforts during unexpected higher intensity rainfall conditions.

4.2 BIOLOGICAL AND WATER QUALITY IMPACTS

4.2.1 General

The water quality, aquatic habitat, and wildlife habitat of Makaleha Stream will be somewhat affected by the proposed project. In a cumulative sense, it is not believed that these impacts will generate any significant impacts upon the Stream biota. Significant impacts are possible if the mitigation efforts identified in sections 4.1 and 4.2 are not carried out during the course of construction. The basis for these conclusions are generally summarized in the following paragraphs. However, a more detailed evaluation of these potential impacts are presented in Appendices C, D, and E.

4.2.2 Aquatic Resources and Related Stream Water Quality

The proposed diversion of water from Upper Makaleha Springs will somewhat degrade the physiochemical characteristics of Makaleha Stream. Given the scope and location of the proposed project, the important environmental parameters influencing the quality of the existing stream biota, e.g. native fish and crustacea, and their habitat, are Stream oxygen, temperature, and sediment levels.

4.2.2.1 Stream Oxygen Levels

Since the upper slopes of Makaleha Stream contains a relatively steep gradient of approximately 14 percent, it is believed that a lowered flow rate will continue to maintain a flow rate which will aerate the surface flow with adequate oxygen (Timbol, 1990). Dissolved oxygen levels recorded during field surveys, made during moderate flow conditions, ranged from 95 to 99 percent saturation in the vicinity of Makaleha Springs and two downstream stations.

4.2.2.2 Stream Temperature Levels

The removal of streamside vegetation may increase exposure of the sun upon Makaleha Stream. Elevated stream temperatures and excessive evaporation could be expected as a consequence of a significant increase in sun exposure. However, this potential impact could be significantly reduced through the use and implementation of the following mitigation measures by the construction contractor:

1. The removal of streamside vegetation will be limited to areas which obstruct the construction of the proposed intake structure and installation of the proposed pipeline. Vegetation will not be removed solely to facilitate site access unless no other practical options are available.

2. Areas that are cleared by the contractor will be replaced with indigenous plants that are approved by the State construction inspector.

4.2.3 Potable Water Quality

Limited sampling and related analyses of the spring waters indicate that the potential water supply is very acceptable for domestic use. It is believed that the proposed intake structure will afford effective protection against potential surface contamination. Because of its proposed setback from the stream, its location will also reduce the likelihood of potential flood inundation during higher stream flow periods.

The design of the proposed intake structure is based on the premise that the perched groundwater, percolating down within the mauka slope of Makaleha Valley, would follow the "dense fracture flow" depicted in Figure 2-3. The impervious rock layer will cause the perched water to travel along the top layer until it reaches the proposed inlet structure. Excavations along the base of the valley wall will be made until the area of "dense fractured flow" is reached. The construction of a cutoff wall type structure is intended to detain and collect the ground water before it reaches the "loose boulders and soil (Figure 2-3).

For security and maintenance purposes, a steel plate cover will be provided on the top of the intake structure. A washout line will also be installed to facilitate periodic flushing of the inlet structure. These design features will also contribute to the maintenance of an acceptable potable water quality.

4.2.4 Wildlife Resources

The proposed project is expected to temporarily reduce available habitat for several exotic and native birds frequenting the Makaleha Stream area. However, this impact is expected to be limited in area and duration if the proposed mitigation measures in sections 4.1 and 4.2 are implemented by the construction contractor. The replacement of removed flora with indigenous plant species will be especially beneficial in terms of providing adequate cover and habitat for the local bird population.

It should be noted that the possible road development discussed in Appendix E is no longer part of the proposed project scope. This decision was made in light of the potential impacts that could occur from such a development.

4.3 BUILT ENVIRONMENT

4.3.1 Increased Domestic Water Supply to the Kapaa-Wailua Service Area

A proposed flow of 500 gpm would provide an additional supply of approximately 0.72 mgd to the County of Kauai's Kapaa-Wailua service area. Assuming a consumption rate of roughly 100 gallons per person per day, the proposed water source development project would create an additional domestic water supply that would be sufficient to support the daily consumption of roughly 7,200 Kauai residents.

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APPENDIX A

DOCUMENTED INFORMATION OBTAINED DURING EIS CONSULTATION

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
4334 RICE ST.
ROOM 104
LIHUE, HI 96766

December 2, 1986

RECEIVED
DEC - 1986
By
to: C.C.

Mr. Glenn Y. Yamamoto
Portugal and Associates, Inc.
4334 Rice St., Suite 204
Lihue, HI 96766

Dear Sir,

The Hawaii DLNR, Division of Water and Land Development's (DOWALD's) proposed site to tap natural springs in the Makaleha mountains is located on soils called Rough Mountainous Land(rRT). These soils occur in mountainous areas on all islands. They consist of very steep land broken by numerous intermittent drainage channels. Over much of the area, the soil is very thin. It ranges from 1 inch to 10 inches of thickness over saprolite material.(weathered bedrock) In most places the saprolite is relatively soft and permeable to water. Rock land, rock outcrop, soil slips, and eroded spots make up 20 to 40 percent of the acreage. This land type is used for water supply, wildlife habitat, and recreation.

There are no engineering interpretations or estimated properties for Rough Mountainous Land but the soil material is similar to that of the Amalu and Olokui soil series.

<u>Features of Each Soil as Taken from the 1972 Soil Survey of Kaua'i</u>

<u>Amalu Soil Series</u>

a) poor source of topsoil because it is always wet
b) soil is a peat and clay mixture
c) poorly drained
d) for foundations of low buildings this soil has high compressibility
e) shrink-swell potential is moderate to low
f) corrosivity is high for both uncoated steel and on concrete

<u>Olokui Soil Series</u>

a) poor source of topsoil because too wet
b) poor compaction characteristics therefore unsuited for road fill
c) low shear strength because of wetness
d) subject to seepage
e) shrink-swell potential is moderate to low
f) corrosivity is high for both uncoated steel and on concrete

In conclusion, because these soils are very steep and wet, care needs to be taken during construction of the concrete basin. Due to limitations of the soils, time of construction needs to be considered to avoid times of heavy rain. Exposed areas of soil need to be revegetated to reduce the hazard of erosion.

Sincerely,

Laurie K. Ho

Laurie K. Ho
Soil Conservationit

attach.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 ALA MOANA BOULEVARD
P. O. BOX 50167
HONOLULU, HAWAII 96850

ES
Room 6307

DEC 2 1986

RECEIVED
DEC - 3 1986
By

Mr. Glenn Y. Yamamoto
Portugal and Associates, Inc.
4334 Rice Street
Suite 204
Lihue, Kauai 96766

Re: Proposed Upper Makaleha Spring Catchment Site, Kauai

Dear Mr. Yamamoto:

We have reviewed your November 17, 1986 letter regarding the proposed project and offer the following comments for your consideration.

Our primary concern with the proposed project is the potential reduction of stream flow in Makaleha Stream and the associated loss of aquatic habitat for native diadromous species such as 'o'opu, 'opae, and hihiwai, endangered koloa (Hawaiian duck), and native insects.

The environmental assessment (EA) should include information on the hydrology of Makaleha Springs and its contribution to discharge in Makaleha Stream. The tapping of the spring and its effect on reducing stream flow should be discussed in the EA. If it is determined that tapping the spring substantially reduces stream flow, further mitigation and compensation measures to protect native aquatic resources will be recommended by our office.

Koloa (Anas wyvilliana), a listed endangered species, may be found in the project area. However, we do not have any current information on their distribution in the area. We recommend that an ornithological survey be conducted to determine the use of the area by koloa and other endangered Hawaiian waterbirds, and to identify potential impacts of tapping the Makaleha springs on these species. This information should be included in the EA. In addition, we recommend that you consult with the Mr. Thomas C. Telfer, Kauai District Biologist, Division of Forestry and Wildlife, Lihue, Kauai.

Native diadromous species, such as 'o'opu, 'opae, and hihiwai may be found in Makaleha Stream. We recommend that aquatic fauna survey(s) be conducted to determine the distribution and abundance of these species in Makaleha upstream and downstream of the project site. The results of these surveys should be included in the EA. We recommend that you contact Mr. Donald Heacock, Aquatic Biologist, Division of Aquatic Resources, Lihue, Kauai.

We appreciate the opportunity to comment.

Sincerely,

Ernest Kosaka

Ernest Kosaka
Project Leader
Office of Environmental Services

cc: DLNR

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, HONOLULU
FT. SHAFTER, HAWAII 96858-5440

February 6, 1986

Portugal, Ibara & Associates, Inc.
RECEIVED
FEB 10 1986
By

REPLY TO
ATTENTION OF
Operations Branch

Mr. Glenn Y. Yamamoto
Portugal, Ibara & Associates, Inc.
4334 Rice Street, Suite 204
Lihue, Hawaii 96766

Dear Mr. Yamamoto:

This is in response to your letter of January 27, 1986 regarding the proposed Makaleha Spring Water Source Development Project in Makaleha Valley, Kapaa, Kauai, Hawaii.

If the proposed project involves any filling of the Makaleha Stream below its ordinary high water mark, a Department of the Army (DA) permit would be required, Likewise, if any fill activity is involved in the construction of any part of a hydropower facility, a DA permit would be required.

At later stages in your study, when more detailed plans are developed on either proposal, we would appreciate the opportunity to review your drawings to determine the DA permit requirements. If you have any further questions on this matter, please contact the Corps Operations Branch at 438-9258.

Sincerely,

Barisa

for Everette A. Flanders
Chief, Construction-Operations Division

GEORGE R. ARIYOSHI
GOVERNOR OF HAWAII

STATE OF HAWAII
DEPARTMENT OF HEALTH
KAUAI DISTRICT HEALTH OFFICE
3040 UMI STREET
LIHUE, HAWAII 96766

LESLIE S. MATSUBARA
DIRECTOR OF HEALTH

JEFFREY A. SMITH, M.D., M.P.H.
DISTRICT HEALTH SERVICES ADMINISTRATOR

Portugal, Ibara & Associates, Inc.
RECEIVED
JAN 22 1986
By

January 20, 1986

Mr. Glenn Y. Yamamoto
Portugal, Ibara and Associates, Inc.
Suite 204
4334 Rice Street
Lihue, Hawaii 96766

Dear Glenn:

SUBJECT: Makaleha Spring Water Source Development, Makaleha Valley, Kapaa, Kauai, Hawaii

We are not aware of any sources of contamination in the area that would adversely affect springs proposed for potable source.

This proposed project should be reviewed by our engineers in Drinking Water Section.

Sincerely,

Ted

Theodore Inouye
Chief Sanitarian, Kauai

TI:CF/plo

HAWAII DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF FORESTRY AND WILDLIFE
KAUAI DISTRICT
P. O. BOX 1671
LIHUE, KAUAI, HAWAII 96766

RECEIVED
DEC 12 1986
By

IN REPLY REFER TO

December 10, 1986

A-3c

Mr. Glenn Y. Yamamoto
Portugal & Associates, Inc.
4334 Rice Street, Suite 204
Lihue, Kauai 96766

Dear Mr. Yamamoto:

The following is in response to your letter of November 17, 1986 relating to environmental assessment of a water project being considered for the Makaleha Stream area in the Kealia Forest Reserve.

The purpose that the Kealia Forest Reserve was established on March 9th, 1906 was specifically for watershed protection for water supply purposes so the proposed use is certainly an appropriate one. Today recreational hunting is also a multiple forest reserve use in the area.

Concerning plant life in the project area, we have no references to any past plant collecting or observation studies in the area and I have not traversed the stream area mauka of the Forest Reserve boundary. It would therefore be important to include provisions for a plant survey along the project route prior to scheduling any active construction work so if there are some sensitive areas alternative actions can be considered.

Concerning wildlife considerations, Wildlife Biologist Tom Telfer, whom manages the Wildlife Branch on Kauai relates the following:

" 1. I have never surveyed the Makaleha Stream area for wildlife;

2. By its location and vegetation, I strongly suspect that the area is inhabited by the Koloa (*Anas wyvilliana*) and the Hawaiian Bat (*Lasiurus cinereus semotus*), both endangered species.

The Hawaiian Gallinule (<u>Gallinula chloropus sandwichensis</u>) and the Newell's Shearwater (<u>Puffinus auricularis newelli</u>) probably are found nearby and could be affected;

3. Before the E.I.S. is prepared, a survey of the plants and wildlife found in the area should be conducted by a competent biologist and botanist; and

4. Since the project site is within the Kealia Forest Reserve (Hunting Unit C), there may be impacts upon the recreational use of the area by hunters, particularly with respect to access, or lack of it. More information is needed on the scope of the project before an evaluation can be made on the environmental impacts to be expected."

Thank you for including us in your early planning of this project.

Kindest regards,

Ralph E. Daehler

RALPH E. DAEHLER
District Forester, Kauai

attachments

cc: Libert K. Landgraf
Roger Evans
Manabu Tagomori

John Waihee
GOVERNOR OF HAWAII

Portugal & Associates, Inc.

RECEIVED
JAN 20 1987
By

STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
DIVISION OF STATE PARKS
P. O. BOX 621
HONOLULU, HAWAII 96809

William W. Paty
Chairperson
BOARD OF LAND & NATURAL RESOURCES

Libert K. Landgraf
DEPUTY TO THE CHAIRMAN

DIVISIONS:
AQUACULTURE DEVELOPMENT PROGRAM
AQUATIC RESOURCES
CONSERVATION AND RESOURCES ENFORCEMENT
CONVEYANCES
FORESTRY AND WILDLIFE
LAND MANAGEMENT
STATE PARKS
WATER AND LAND DEVELOPMENT

January 14, 1987

Mr. Glenn Yamamoto
Portugal and Associates, Inc.
4334 Rice Street, Suite 204
Lihue, Hawaii 96766

Dear Mr. Yamamoto:

Subject: Field Inspection Report -- Makaleha Stream Well Project, DLNR, Division of Water and Land Development (DOWALD)
Kealia Forest Reserve, Kawaihau, Kauai
TMK: 4-6-01:portion of 1

On December 19, 1986 Wendell Kam, our staff archaeologist handling Kauai County, conducted a field inspection of the proposed project area (see attached Maps 1 and 2). The purpose of the inspection was to evaluate the recommendations and results of the archaeological reconnaissance survey completed by Cultural Surveys Hawaii (October 20, 1986) for the subject area.

The inspection consisted of walking along the proposed pipeline route (see Map 2) beginning at the existing 1,000,000 gallon water tank (see Photographs 1 - 4). As stated in the archaeological reconnaissance survey (1986:1), the upper half of the proposed pipeline route above the Lihue Plantation diversion becomes heavily vegetated and the valley narrows to the extent that it would be highly unlikely that any agricultural terraces could have been built there. Thus, we concur with the survey's conclusion that "no terraces were found in the project area" (1986:2).

However, there exists the possibility that construction of the proposed access road may expose historic sites which may be currently covered by dense vegetation. To deal with this possibility, we recommend that the applicant notify our office at least thirty days prior to construction of the road, so we can possibly make arrangements to have a Staff Archaeologist monitor the road construction activities while on island for other purposes.

Should you have any further questions, please contant Mr. Kam at 548-7460.

Sincerely,

RALSTON H. NAGATA
State Parks Administrator

Attachments (2 maps, 4 photographs)

cc: Paul Matsuo, DOWALD

TONY T. KUNIMURA
MAYOR

COUNTY OF KAUAI
PLANNING DEPARTMENT
4280 RICE STREET
LIHUE, KAUAI, HAWAII 96766

AVERY H. YOUN
PLANNING DIRECTOR

TOM H. SHIGEMOTO
DEPUTY PLANNING DIRECTOR

TELEPHONE (808) 245-3919

RECEIVED
DEC - 1 1986
By

November 26, 1986

Mr. Glenn Yamamoto
Portugal & Associates, Inc.
4334 Rice Street, Suite 204
Lihue, Hawaii 96766

Subject: Proposed Spring Catchment
Makaleha Mountains, Kauai

In response to your letter dated November 17, 1986, we have reviewed the maps submitted and have determined that the project site is located outside the Special Management Area of the County of Kauai. As such, no SMA permit is required.

Thank you for consulting us on this matter.

for Tom H. Shigemoto
AVERY H. YOUN
Planning Director

1087

Portugal & Associates, Inc.
RECEIVED
MAR 3 0 1987
By

RECEIVED
87 MAR 9 9:54

THE LIHUE PLANTATION CO., LTD.

P.O. BOX 751
LIHUE, HAWAII 96766

February 18, 1987

Mr. William W. Paty, Jr.
Chairperson of the Board
Board of Land and
Natural Resources
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Subject: Proposed Withdrawal of Waters from Makaleha Spring, G.L. S-3827

Dear Mr. Paty:

We have received your January 20, 1987 letter notifying us of DLNR's intention to withdraw 720,000 gpd from the Makaleha Spring source that is currently covered under our East Kauai Water Co. GL S-3827. We have several substantive concerns with this action which need to be addressed before we can concur with such a withdrawal and waive our contractural right to adequate advanced notice.

The primary concerns are summarized as follows:

1) Paragraph 11 of GL S-3827 states in part "Any development or diversion of water from the drainage area by any person other than the Lessee under the General Lease No. 3827 which results in a diversion of less than fifty (50) million gallons of water per day by said Lessee during the months of June, July, August and September shall be deemed an unreasonable interference with the then existing operations of the Lessee . . ." Our analysis shows that over the last ten (10) years, substantially more than half of the average monthly flows for the June to September period have been below fifty (50) mgd with some months as low as twenty-seven (27) mgd. Further taking of waters from the system is in conflict with Paragraph 11 and could be construed as an "unreasonable" interference.

2) The existing Makaleha intake is one of the few dependable sources to provide water to our Kealia fields. This area is already a water deficit area and subject to a severe seasonal water shortage. Lihue Plantation Co. has invested substantially

in water conservation efforts in Kealia including drip irrigation, yet the supply of waters to Kealia remain an ongoing concern. Any additional reductions in our current supply of water to Kealia pose a threat to future crop viabilities in that area.

3) The Kauai Department of Water Supply proposes to withdraw 720,000 gpd from new intakes to be constructed upstream from the Makaleha Ditch. This amounts to 16% of the stream's base flow which is most critical during dry periods. The intake system that is being proposed, however, has the capacity to take twice as much water as is being requested with no apparent mechanism to meter and monitor the withdrawal on a regular basis.

As you are well aware, the value of water to an agricultural operation is amplified at times of seasonal shortage. During a portion of the year, the withdrawal for domestic use may have no substantive effect on our current operations. Our concerns are focused on times of shortage and the need to protect our supplies when they are most needed.

Given all the above, we would like to request a meeting with your department to discuss our concerns to be scheduled at your earliest convenience.

Sincerely,

H Kawazoe

Lefty H. Kawazoe
President and Manager

LK:JM/kk

xc: B. Hatton
S. Hance

Portugal ...

RECEIVED
FEB 19 1987
By

Box 641
Honolulu, HI. 96809
February 13, 1987

Mr. Glenn Yamamoto
Portugal & Associates, Inc.
4334 Rice St., Suite 204
Lihue, Hi. 96766

Dear Mr. Yamamoto:

SUBJECT: Proposed Upper Makaleha Springs Water Resource Development, Makaleha Mountains, Kaua'i. TMK: 4-6-01: 1

I am an archaeologist working in the Office of Hawaiian Affairs, and it is important to me to be well informed regarding current projects in Hawaiian archaeology. As archaeological resources are subject to state and federal laws, I anticipate that archaeological studies will be required for the above undertaking, which is in an area likely to contain significant archaeological resources. Please send me a copy of all archaeological studies sponsored by the proposed undertaking, including preliminary reports, reconnaissance survey reports, comprehensive survey reports, salvage excavation reports, monitoring reports, data recovery plans, research designs, and cultural resources management plans. Mahalo for your help.

Aloha,

Earl Neller

Earl Neller

APPENDIX B

RESPONSES TO THE DRAFT EIS

JOHN WAIHEE
GOVERNOR OF HAWAII

DISTRICT OFFICES

WEST HAWAII OFFICE
P. O. BOX 125
KAMUELA, HAWAII 96743

EAST HAWAII OFFICE
160 BAKER STREET
HILO, HAWAII 96720

STATE OF HAWAII
DEPARTMENT OF HAWAIIAN HOME LANDS
P. O. BOX 1879
HONOLULU, HAWAII 96805

DISTRICT OFFICES

MAUI OFFICE
P. O. BOX HHH
WAILUKU, MAUI 96793

MOLOKAI OFFICE
P. O. BOX 198
HOOLEHUA, MOLOKAI 96729

KAUAI OFFICE
P. O. BOX 332
LIHUE, KAUAI 96766

September 15, 1987

RECEIVED
OCT - 6 1987
By

Dr. Marvin T. Miura, Director
Office of Environmental Quality Control
465 South King Street, Room 104
Honolulu, Hawaii 96813

Dear Dr. Miura:

SUBJECT: EIS: Upper Makaleha Springs
Water Resource Development

This project seems to be a sensible, cost-effective means of tapping an under-used water resource for a large growth area. Because this source already provides some supply to a Hawaiian Home Lands lessee, we must state the following concerns, which are not reported in the environmental impact statement. Foremost, further development of Makaleha Springs should reserve a portion of the yield to Department of Hawaiian Home Lands' (DHHL's) beneficiaries.

DHHL has both a constitutional and a development interest in Makaleha Springs water. The Hawaiian Homes Commission Act authorizes DHHL "to use, free of all charge, government-owned water not covered by any water license or covered by a water license issued after the passage of this Act or covered by a water license issued previous to the passage of this Act but containing a reservation of such water for the benefit of the public." (Sec. 221 (c), Hawaiian Homes Commission Act, 1920, as amended.) The proposed Anahola Development Plan calls for additional water development, primarily for domestic homestead use and secondarily for agricultural uses.

Further, the viability of sugar cultivation on Lihue Plantation leased lands impacts DHHL revenues, as 30% of all State sugar lease receipts feed the Native Hawaiian Rehabilitation Fund. We note the concerns of Lihue Plantation Company that the proposed action will reduce the water available for its sugarcane cultivation and possibly infringe on its lease rights under General Lease S-3827 for the agriculture lands at Kealia.

Finally, should Lihue Plantation find it necessary to consolidate activities, homestead lands might be opened up sooner. With Makaleha water available, this will have a significant impact on current planning for the sizing of new well development.

For these reasons, we are concerned with the long-term distribution of Makaleha Springs water. They are plainly issues that need to be addressed in the environmental impact statement.

The document does not discuss storage options, although it appears to us that there may be significant advantages to increasing capacity, especially for residential use during the dry season. Such storage might be fed by the proposed spring intake, during the period when spring waters are not being diverted for agriculture.

Conservation measures are mentioned as integral to any water supply program rather than as alternatives to the project, but none are discussed. It seems to us that currently available fixtures, especially coupled with water rate incentives, could significantly impact overall demand, at very low cost.

Thank you for the opportunity to comment. You may refer any questions to Charley Ice of our Planning Office at 548-8785.

Sincerely,

Ilima Piianaia

Ilima A. Piianaia, Chairman
Hawaiian Homes Commission

IAP:CI:eh

PORTUGAL & ASSOCIATES, INC.
P.O. Box 807
Lihue, Kauai, Hawaii 96766
Tel: (808) 245 - 6749
Fax: (808) 246 - 9391

November 25, 1990

Ms. Hoaliku Drake
Chairperson
Hawaiian Homes Commission
State Department of Hawaiian Homes Lands
P.O. Box 1879
Honolulu, Hawaii 96805

Dear Ms. Drake:

Subject: Draft Environmental Impact Statement
Upper Makaleha Springs Water Resource Development Project
Kapaa, Kauai

We are in receipt of your correspondence to Dr. Marvin Miura dated September 15, 1987. We appreciate the time that you and other members of your department have expended to review this project. The project has been considerably delayed to our performance of additional field studies and related modifications to our preliminary design plans and draft EIS document.

The final EIS addresses the loss in flows presented diverted to Lihue Plantation Company for the irrigation of some 1000 acres of sugar cane. Since preparation of the draft EIS, my staff has met with representatives of the East Kauai Water Company, Ltd.; however, these discussions have not yielded any definitive information concerning the true impact upon sugarcane field irrigation. However, our estimates in the final EIS indicate that, in the worst case, the diversion of water for domestic supplies would adversely affect some 75-150 acres of sugar cane lands in production.

In terms of the use of HHL land for residential purposes, we concur that the development of additional water source(s) should only expedite such proposals. The delay of such development would only further deter the potential use of HHL lands for residential purposes.

In terms of water storage options, we do not share your concept that additonal water storage would increase capacity because the existing 1.0 mgd is often depleted of its present storage capacity.

We agree that water conservation is an integral part of any water supply program. "Water savings" generated via a conservation program would help the present water system better accommodate maximum day demands. However, anticipated population growth in the Kapaa-Wailua area during the next 20 years cannot be supported by only "water savings" obtained through water conservation. Consequently, water conservation was identified as a viable project alternative.

Since your review of the draft EIS, the performance of additional field studies has led us to somewhat modify the proposed project. Specifically, the earlier concept of constructing an access road along Makaleha Stream has been eliminated from the overall project scope. Further, the contractor will not be permitted to mobilize land vehicles past the mauka end of Kahuna. Consequently, the stream will not be unnecessarily impacted by construction activities and roadway development.

Many thanks for your thoughtful comments which were very useful in our preparation of the final EIS. Thank you also for your patience in receiving our response to your comments to the draft EIS. However, we feel that the delay has been fruitful in terms of reducing the potential environmental consequences of the project and refining the overall approach to water resource development in Kauai's Kapaa-Wailua area.

Should you have any questions, please contact us at your convenience.

Sincerely,

Cesar C. Portugal
President-Treasurer

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 ALA MOANA BOULEVARD
P. O. BOX 50167
HONOLULU, HAWAII 96850

Dr. Marvin T. Miura, Director
Office of Environmental Quality Control
465 South King Street, Room 104
Honolulu, Hawaii 96813

Re: Draft Environmental Impact Statement, Upper Makaleha Springs Water Resource Development Project, Kapaa, Kauai

Dear Dr. Miura:

We have reviewed the referenced Draft Environmental Impact Statement (EIS) and offer the following comments for your consideration.

General Comments

The proposed diversion of approximately 1.1 cubic feet per second from the Upper Makaleha Springs may decrease streamflow in Makaleha Stream. The reduction in streamflow may reduce the amount of habitat available for native freshwater species such as o'opu alamo'o (Lentipes concolor), o'opu nakea (Awaous stamineus), and 'opae kala'ole (Atyoida bisulcata). Road construction and increased human activity within the project site may reduce the stream's value as habitat for the endangered Hawaiian Duck (Anas wyvilliana).

no construction road shall be built

The State Water Code provides for the dedication of instream flows to protect and maintain fishery and wildlife resources by establishing instream flow standards. The Water Code requires that interim instream flows for Kauai be established by December 31, 1987.

Specific Comments

a. Page 4. Proposed Structures. The adjustable intake structure that regulates the amount of water entering the basin is not described. A description of the intake structure should be described in the Draft EIS.

b. Page 7. Drill a New Well at Akulikuli Ridge. The alternative of well drilling at Akulikuli Ridge is not considered since "recent geological studies suggest there is little or no high level dike-confined groundwater in the Makaleha area." These geological studies should be referenced.

c. Page 9. Physical Aspects of Makaleha Stream Valley. The Draft EIS should provide additional information on the frequency and magnitude of water diversion by Lihue Plantation on stream flow in Makaleha Stream.

d. Page 10. The assumption that Upper Makaleha Springs contributes approximately 17% of the streamflow in Makaleha Stream is based on "few measurements." A more complete study of the discharge of Upper Makaleha Springs and its relative contribution to Makaleha Stream should be conducted. Reliable information on the contribution of spring flow on Makaleha Stream is important in determining the magnitude of potential adverse impacts to stream habitats and water quality.

e. Page 18. Long Term Effects. This section states that additional springwater will be released into the stream if the new diversion affects stream fauna. However, a monitoring program to determine adverse impacts to native stream fauna is not described. The Draft EIS should discuss the monitoring study.

f. The alignment of the access road along Makaleha Stream should be coordinated with our office and the Division of Forestry and Wildlife to minimize potential adverse impacts to stream habitats.

Summary Comments

The Draft EIS does not adequately address the following issues:

a. The relationship of the proposed springs diversion project to the State Water Code and instream flow standards is not discussed. Specifically, the Draft EIS should discuss the establishment of biologically defensible instream flow standards to protect native stream fauna and endangered Hawaiian waterbirds in the affected stream reach.

b. The contribution of springflow from the Upper Makaleha Springs to streamflow in Makaleha Stream is not well documented. We recommend additional hydrological studies to determine the contribution of springwater to streamflow.

If the project is funded, authorized, or carried out by any Federal agency, and if the project may affect any listed endangered or threatened species, Section 7 of the Endangered Species Act requires that such a project be reviewed by the Service to determine the extent of possible impacts on those species.

Re: Makaleha Springs Diversion Project

We appreciate the opportunity to comment.

Sincerely,

William R. Kramer
for Ernest Kosaka
Project Leader, Environmental Services
Pacific Islands Office

cc: DLNR
✓DOWALD
CE, Operations Branch

PORTUGAL & ASSOCIATES, INC.
P.O. Box 807
Lihue, Kauai, Hawaii 96766
Tel: (808) 245 - 6749
Fax: (808) 246 - 9391

November 25, 1990

Mr. Ernest Kosaka
Project Leader, Environmental Services
Pacific Islands Office
U.S. Fish and Wildlife Service
300 Ala Moana Boulevard
P.O. Box 50167
Honolulu, Hawaii 96850

Dear Mr. Kosaka:

Subject: Draft Environmental Impact Statement
Upper Makaleha Springs Water Resource Development Project, Kapaa, Kauai

Thank you for your letter to Dr. Marvin Miura dated September 8, 1987. We appreciate the time that you and your staff took to review this project. The project has been delayed to our performance of additional field studies and related modifications to our preliminary design plans and draft EIS document.

The comments that you and your staff provided to us assisted us greatly in our substantive revision of the draft EIS. In preparation of the final EIS, each of your general comments prompted the inclusion of greater analyses and discussion concerning the impact of decreased streamflow upon native aquatic resources and the surface water quality of Makaleha Stream.

Additional information has also been presented concerning the proposed intake structure, the physical characteristics of Makaleha Stream and the adjoining valley, the contribution of Makaleha Spring flows to overall Stream flows, and the relationship of the proposed project to the instream flow standards.

More significantly, the performance of additional field studies has led us to modify the proposed project. Specifically, the earlier concept of constructing an access road along Makaleha Stream has been eliminated from the overall project scope. Further, the contractor will not be permitted to mobilize land vehicles past the mauka end of Kahuna. Consequently, the stream will not be unnecessarily impacted by construction activities and roadway development.

Thank you for your patience in receiving our response to your comments to the draft EIS. However, we feel that the delay has been fruitful in terms of reducing the potential environmental consequences of the project.

Should you have any questions, please contact us at your convenience.

Sincerely,

Cesar C. Portugal
President-Treasurer

University of Hawaii at Manoa

Environmental Center
Crawford 317 • 2550 Campus Road
Honolulu, Hawaii 96822
Telephone (808) 948-7361

RECEIVED
NOV - 2 1987
By ....

October 28, 1987
(RE:0469)

Dr. Marvin T. Miura, Director
Office of Environmental Quality Control
465 South King Street, Room 104
Honolulu, Hawaii 96813

Dear Dr. Miura:

Response to Environmental Center Comments
Draft Environmental Impact Statement
Upper Makaleha Springs Water Resources Development
Kapaa, Kauai

The Environmental Center submitted comments on the Draft EIS for Upper Makaleha Springs Water Resources Development on September 8, 1987, (RE:0469). In our review, we called attention to the general inadequacy of the document, the absence of quantitative studies and mitigative plans, the lack of development of alternatives, deficiencies in assessment of biological impacts, the need for assessment of instream water uses, health risks, road construction impacts, and highly significant water rights issues.

The initial review and these subsequent comments regarding the above mentioned document were prepared with the assistance of Leonard Freed, Zoology; Michael Graves, Anthropology; DeWolfe Miller, School of Public Health; Edwin Murabayashi, Henry Gee, and Yu-Si Fok, Water Resources Research Center; James Parrish, Hawaii Cooperative Fishery Research Unit; Frank Peterson, Geology and Geophysics; and John Harrison and Steven Armann, Environmental Center.

We agree that the "draft Environmental Impact Statement does not attempt to discuss in greatest detail every aspect of the proposed project". However, the purpose of the EIS is to provide substantive information on a proposed action and to disclose the environmental effects of the action. If the information exists elsewhere, as the response letter states, then it should be summarized and referenced within the Draft EIS so that a comprehensive evaluation can be made in accordance with the EIS regulations (11-200-19). If the information is not available, consultants must be hired to provide the needed studies.

The response to our review is superficial and inadequately addresses the issues and concerns we raised. The questions and the present concerns need to be adequately addressed before the EIS is considered for acceptance. It is not the responsibility of the readers to seek out, or compile the pertinent information.

This document does not satisfy the content requirements of an EIS as set forth in the regulations, and the response to comments submitted during the review phase is not supported by quantitative data or referenced studies. The document should not be accepted until the deficiences identified in the review phase are adequately addressed.

Lihue Plantation Company

The basis for the statement regarding the assumption that 16 percent of the spring water irrigation system flow to Lihue Plantation will be reduced, is not supported or referenced. The 16 percent figure needs to be substantiated quantitatively with a hydrological study. What is the base flow for Makaleha Stream; who conducted the base flow study; when was the base flow study conducted? What economic data were used to evaluate the effect of a 16 percent irrigation water reduction on Lihue Plantation? Can the company survive a 16 percent reduction in output? What will be the socio-economic impacts to the community should the plantation fold?

Responsibility is inappropriately placed on Lihue Plantation for the mitigative measures suggested in the response letter. The Kauai Department of Water Supply should be the responsible party for initiating mitigation measures to reduce the impacts to current users, ie. Lihue Plantation. Furthermore, we suspect that many of the proposed suggestions for improving the "effective and efficient use of the available water with minimal waste" are already practiced by the Plantation. For example, it is our understanding that Lihue Plantation already employs the drip irrigation system over much of their lands.

The "unmetered and unmonitored" diversion of water may be the policy of the Lihue Plantation at the present time; however their policy should not set a precedent for the Kauai Department of Water. Monitoring and regulatory control should be conducted, and our question was and still is, "what regulatory agency will insure that the Kauai Department of Water will monitor base stream flow in Makaleha Stream?"

The certainty of impact is never known before a project is developed. However, methods have been developed to estimate the potential impacts, and we previously suggested that plotting a duration curve or doing an Instream Flow Incremental Model (IFIM) study would help to estimate potential impacts. We believe that such analyses are necessary considering the quality of the environment in Makaleha Valley. Such studies can identify potential problems and permit planning for adequate mitigation measures so as to avoid unnecessary impacts.

Road Construction

The response stated that "design of the proposed waterline and access roadway, has not been completed", therefore, "details of the improvements are not available at this time." The purpose of the EIS is not met, if the impacts of the action cannot be reasonably evaluated. The response suggests that the EIS process is premature for this project. The statement that "the proposed pipeline shall be located as far away from the stream as deemed practical" inadequately defines the distance. What guidelines will be used to determine the definition of "practical" distance?

Alternatives

No response is provided to our comments regarding the inadequacy of the discussion of alternatives.

Summary

The Draft EIS document and the responses given do not provide adequate information by which to evaluate the potential environmental impacts of this project. The information is very superficial and based on assumptions and unsubstantiated approximations rather than quantitative or verifiable studies. It is apparent that some of the deficiencies can be traced to inadequate project planning before the preparation of the EIS. We urge that significant modifications and amendments of this document be required, and that an additional review of these amendments be solicited prior to acceptance of the EIS.

In closing, this EIS presents a very adversarial position toward Lihue Plantation. Water is essential to both the Kauai Department of Water Supply and the Plantation. Cooperative solutions to the respective needs of each are needed, not confrontational dialogue.

We appreciate the opportunity to comment and hope our comments will be taken into consideration.

Yours truly,

Jacquelin N. Miller

Jacquelin N. Miller
Associate Environmental Coordinator

cc: Portugal & Associates, Inc.
L. Stephen Lau
Leonard Freed
Yu-Si Fok
Henry Gee
Michael Graves
DeWolfe Miller
Edwin Murabayashi
James Parrish
Frank Peterson
John Harrison
Steven Armann

PORTUGAL & ASSOCIATES, INC.
P.O. Box 807
Lihue, Kauai, Hawaii 96766
Tel: (808) 245 - 6749
Fax: (808) 246 - 9391

November 25, 1990

Mr. John Harrison, Director
U.H. Environmental Center
University of Hawaii at Manoa
2550 Campus Road, Crawford 317
Honolulu, Hawaii 96822

Dear Mr. Harrison:

Subject: Draft Environmental Impact Statement
Upper Makaleha Springs Water Resource Development Project, Kapaa, Kauai

We are in receipt of correspondence from Ms. Jacquelin Miller to Dr. Marvin Miura dated October 28, 1987. We appreciate the time that you and other affiliate staff of the Environmental Center expended to review this project. The project has been considerably delayed to our performance of additional field studies and related modifications to our preliminary design plans and draft EIS document.

We recognize the deficiencies of the draft EIS and concur that various revisions were required to satisfy the content requirements for an EIS. The final EIS has been substantively revised to include a full discussion and comparison of project alternatives and the potential impacts of diverting additional streamflow from Makaleha Stream. We have also incorporated a number of mitigation measures into the final EIS which we intend to incorporate into the design plans and specifications for this project.

While an Instream Flow Incremental Model was not established to further evaluate the project, additional evaluations were made of the potential impacts upon the water quality, aquatic resources and wildlife of the Stream environment.

More significantly, the performance of additional field studies has led us to somewhat modify the proposed project. Specifically, the earlier concept of constructing an access road along Makaleha Stream has been eliminated from the overall project scope. Further, the contractor will not be permitted to mobilize land vehicles past the mauka end of Kahuna. Consequently, the stream will not be unnecessarily impacted by construction activities and roadway development.

Thank you for your patience in receiving our response to your comments to the draft EIS. We feel that the delay has been fruitful in terms of reducing the potential environmental consequences of the project and refining the overall approach to water resource development.

Should you have any questions, please contact us at your convenience.

Sincerely,

Cesar C. Portugal
President-Treasurer

WSL

John Waihee
GOVERNOR OF HAWAII

John C. Lewin, M.D.
DIRECTOR OF HEALTH

STATE OF HAWAII
DEPARTMENT OF HEALTH
P. O. BOX 3378
HONOLULU, HAWAII 96801

February 24, 1987

RECEIVED APR - 3 1987

By ....

In reply, please refer to:
EPHSD

MEMORANDUM

To: Honorable William W. Paty, Chairperson
Board of Land and Natural Resources

From: Director of Health

Subject: Environmental Assessment for Upper Makaleha Springs Water Resource Development, Kauai

Thank you for allowing us to review and comment on the subject environmental assessment. The Drinking Water Program has reviewed the Environmental Assessment and it is our understanding that DLNR plans to tap the springs in the Makaleha Mountains on the east side of Kauai to provide water for the Kapaa water system.

Please be advised that the decision to use this spring or other new sources as a source of potable water will require compliance with Section 11-20-29, Chapter 20, Title 11, Administrative Rules. This Section requires Department of Health approval of all new potable water sources serving public water systems. Such approval is based upon the submission of an engineering report satisfactorily addressing all concerns set down in Section 11-20-29, Chapter 20, Title 11, Administrative Rules.

Concerns for water sources identified in Section 11-20-29 of Chapter 20, Title 11, include but are not limited to:

1. Nature of the soil and stratum overlaying the water source;

2. Nature, distance, direction of flow and time of travel of contaminants from present and projected domestic, industrial and agricultural sources of pollution, and waste injection wells and other waste disposal facilities;

3. Probability and effect of surface drainage or contaminated underground water entering the subject water source;

4. Water quality and quantity data during normal and stress periods.

Your careful review of these and other concerns as set down in Section 11-20-29, Chapter 20 is urged. Your consideration and use of this information in the determination of sites for water sources of this nature will serve to avoid possible conflicts in use of resources.

Honorable William W. Paty
February 24, 1987
Page 2

Should you have any questions concerning Chapter 20, Title 11, Administrative Rules, please feel free to contact the Drinking Water Program at 548-2235.

JOHN C. LEWIN, M.D.

cc: DHO, Kauai

PORTUGAL & ASSOCIATES, INC.
P.O. Box 807
Lihue, Kauai, Hawaii 96766
Tel: (808) 245 - 6749
Fax: (808) 246 - 9391

November 25, 1990

Mr. John C. Lewin, M.D.
Director of Health
State Department of Health
P.O. Box 3378
Honolulu, Hawaii 96801

Dear Dr. Lewin:

Subject: Draft Environmental Impact Statement
Upper Makaleha Springs Water Resource Development Project, Kapaa, Kauai

We are in receipt of your correspondence to Mr. William Paty dated February 24, 1987. We appreciate the time that you and other members of your department have expended to review this project. The project has been considerably delayed to our performance of additional field studies and related modifications to our preliminary design plans and draft EIS document.

We appreciate your advising us of the requirements of Section 11-20-29, Chapter 20, Title 11, Administrative Rules. We have incorporated this information into the final EIS for this project. An engineering report has already been prepared for the project by our firm which addresses the requirements of Section 11-20-29.

Since your review of the draft EIS, the performance of additional field studies has led us to somewhat modify the proposed project. Specifically, the earlier concept of constructing an access road along Makaleha Stream has been eliminated from the overall project scope. Further, the contractor will not be permitted to mobilize land vehicles past the mauka end of Kahuna. Consequently, the stream will not be unnecessarily impacted by construction activities and roadway development.

Thank you for your patience in receiving our response to your comments to the draft EIS. However, we feel that the delay has been fruitful in terms of reducing the potential environmental consequences of the project and refining the overall approach to water resource development.

Should you have any questions, please contact us at your convenience.

Sincerely,

Cesar C. Portugal
President-Treasurer

DEPARTMENT OF BUSINESS
AND ECONOMIC DEVELOPMENT

KAMAMALU BUILDING, 250 SOUTH KING ST., HONOLULU, HAWAII
MAILING ADDRESS: P.O. BOX 2359, HONOLULU, HAWAII 96804 TELEX: 7430250 HIDPED

JOHN WAIHEE
GOVERNOR
ROGER A. ULVELING
DIRECTOR
MURRAY E. TOWILL
DEPUTY DIRECTOR
BARBARA KIM STANTON
DEPUTY DIRECTOR

Ref. No. P-7357

September 29, 1987

RECEIVED
OCT - 5 1987
By

Mr. Glenn Y. Yamamoto
Portugal & Associates, Inc.
4444 Rice Street
Lihue, Hawaii 96766

Dear Mr. Yamamoto:

Subject: Draft Environmental Impact Statement, Upper Makaleha Springs Water Resource Development Kapaa, Hawaii

Thank you for your September 21, 1987, response to our comments on the subject document. Your response is helpful in further understanding the various alternative activities of the project, their potential impacts and corresponding mitigating measures. However, in the first paragraph of your response under the Hawaii Coastal Zone Management Program heading, you contend that "an assessment and discussion of the overall project relative to CZM objectives and policies are not necessary."

This is not an uncommon misconception of the scope of application of the CZM program. I believe the CZM map to which you refer describes the special management area (SMA) for the County of Kauai. SMA's include coastal regions of the State that are more closely scrutinized through a County administrated permit and review process. This part of the CZM program is described in Chapter 205A, Part II of Hawaii Revised Statutes. Broader application of the program objectives and policies are provided for in Chapter 205A-1 (2), Part II, to include all lands in the State with the exception of forest reserves and Federal lands.

Should you have any questions on this matter, please do not hesitate to contact our CZM staff at 548-8465.

Sincerely,

Murray E. Towill

Roger A. Ulveling

PORTUGAL & ASSOCIATES, INC.
P.O. Box 807
Lihue, Kauai, Hawaii 96766
Tel: (808) 245 - 6749
Fax: (808) 246 - 9391

November 25, 1990

Mr. Roger A. Ulveling
Director
State Department of Business and Economic Development
P.O. Box 2359
Honolulu, Hawaii 96804

Dear Mr. Ulveling:

Subject: Draft Environmental Impact Statement
Upper Makaleha Springs Water Resource Development Project, Kapaa, Kauai

We are in receipt of your correspondence to Mr. Glenn Yamamoto dated September 29, 1987. We appreciate the time that you and other members of your department have expended to review this project. The project has been considerably delayed to our performance of additional field studies and related modifications to our preliminary design plans and draft EIS document.

We are grateful for your clarification of Chapter 205A and the broader application of CZM program objectives and policies. The final EIS has been revised to reflect your comments. In addition, we have identified those CZM objectives and policies that we believe are relevant to the proposed project.

Since your review of the draft EIS, the performance of additional field studies has led us to somewhat modify the proposed project. Specifically, the earlier concept of constructing an access road along Makaleha Stream has been eliminated from the overall project scope. Further, the contractor will not be permitted to mobilize land vehicles past the mauka end of Kahuna. Consequently, the stream will not be unnecessarily impacted by construction activities and roadway development.

Thank you for your patience in receiving our response to your comments to the draft EIS. However, we feel that the delay has been fruitful in terms of reducing the potential environmental consequences of the project and refining the overall approach to water resource development.

Should you have any questions, please contact us at your convenience.

Sincerely,

Cesar C. Portugal
President-Treasurer

APPENDIX C

AQUATIC BIOLOGICAL STUDIES

Amadeo Timbol, Ph.D.

A DESCRIPTIVE STUDY OF SELECTED BIOLOGICAL AND PHYSICOCHEMICAL CHARACTERISTICS OF MAKALEHA STREAM, KAUAI

by

Amadeo S. Timbol, Ph. D.
Aquatic Biologist

Prepared for

PORTUGAL AND ASSOCIATES, INC.
4444 RICE STREET, SUITE 109
LIHUE, Kauai, Hawaii 96766

May 8, 1990

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1. INTRODUCTION

Makaleha Stream is a tributary of Kapaa Stream in Kapaa town on eastern Kauai (Fig. 1). It is perennial (flows year round). In 1986, a biological reconnaissance was done for Portugal and Associates, Inc. for use in the preparation of a draft EIS for a proposed well for the Kauai County Board of Water Supply (Timbol 1986). The draft EIS elicited questions regarding the native goby fishes living in Makaleha. Aside from this study, there are no other published data on the aquatic macrofauna in Makaleha Stream.

1.1 Study Personnel and Acknowledgments

Brady Tokuda and Michael Kido, M. S. assisted in the field work. Tokuda helped in backpacking scientific equipment and Kido assisted in the census of the fish and crustacea.

1.2 Aquatic macrofauna in Hawaiian streams.

The fauna is characterized by low diversity of species and a high degree of endemism. In the upper reaches, the predominant native fishes are gobiids. All the native fishes that are restricted to fresh water as adults are diadromous. (Diadromy is a designation for species which are migratory between fresh and salt water). Adult gobies spawn over a period of months in freshwater, mostly in the lower reaches of streams. Hatchlings are carried out to sea by stream current where they spend a marine existence as plankton. These then metamorphose into post-larvae (hinana) near the mouths of streams, settle on appropriate substrata, and migrate upstream to their places of permanent residences (Ego 1956, Tomihama 1972, Maciolek 1977, Timbol, et al. 1980, Kinzie and Ford 1982). These gobiids, as well as most native fresh water macrofauna, therefore, must have suitable environment throughout the stream channel for their upstream and downstream migrations.

This study involves that portion of the Makaleha Stream from just above Makaleha spring down to just below the Lihue Plantation Co. diversion weir. The location of the Makaleha Stream, the spring, and diversion weir are shown in Figure 2. Appendix A includes pictures of the spring, diversion weir, and the control gate to the Makaleha tunnel and ditch.

1.2 Scope of Report

This study is intended to update the 1986 biological data and to determine the physicochemical conditions in which the biota live. These data are needed in order to address the concerns of the Office of Environmental Quality Control in regards to the aquatic life. This report covers six field-work days: March 19, 20, 23, 29, 30 and April 8, 1990.

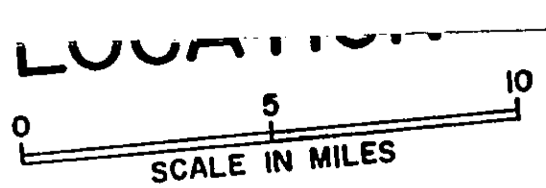

Figure 1. Map of Kauai showing the location of Makaleha Stream (in rectangle). Adapted from Portugal and Associates, Inc. map, 1986.

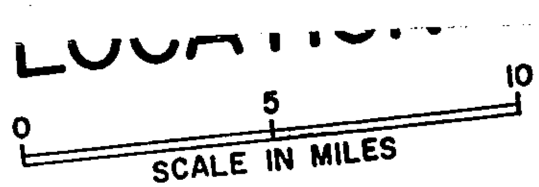

Figure 1. Map of Kauai showing the location of Makaleha Stream (in rectangle). Adapted from Portugal and Associates, Inc. map, 1986.

1.3 Objectives of the Study

The main purpose of this study is to compile a short-term baseline description of that part of Makaleha Stream that may be affected by the proposed county well. It covers about one mile of stream channel. The specific objectives are to:

1. Compile an aquatic macrofauna list consisting of both scientific and local or common names.

2. Make a semi-quantitative estimate of fish, decapod crustaceans and stream macrobenthos.

3. Describe the stream's physicohcemical characteristics, i.e. dissolved oxygen, water temperature, pH, conductance and turbidity.

4. Describe that part of the Makaleha Stream that could be affected by the proposed well using the designated sampling stations as representative stream channel. This involves width, depth, longitudinal gradient, stream substrata, flow velocity and discharge.

5. Identify riparian vegetation on both banks of the sampling stations and estimate the vegetative canopy covering stream channel.

6. Based on the biological and physicochemical features to make an educated guess as to the continued presence of the endemic animals in the stream.

2. MATERIALS AND METHODS

2.1 Sampling Stations

Three sampling stations were studied. Their approximate locations are shown in Figure 2. In this report, station I is also referred to as the "upper " station, station II as "spring" station, and station III as the "weir" station. Pictures of these stations are shown in Appendix A.

2.2 Biological Features

2.2.1 Fish and crustaceans. Fishes, crustaceans and mollusks were counted with the aid of a face mask and snorkel. Boulders, rocks and stones were examined for mollusks. The advantages and disadvantages of the visual method compared with the use of an electroshocker are discussed by Maciolek and Timbol (1980), Timbol and Maciolek (1978), Larimore (1961) and Riggs (1953). The data were converted to number of individuals per 20 meters

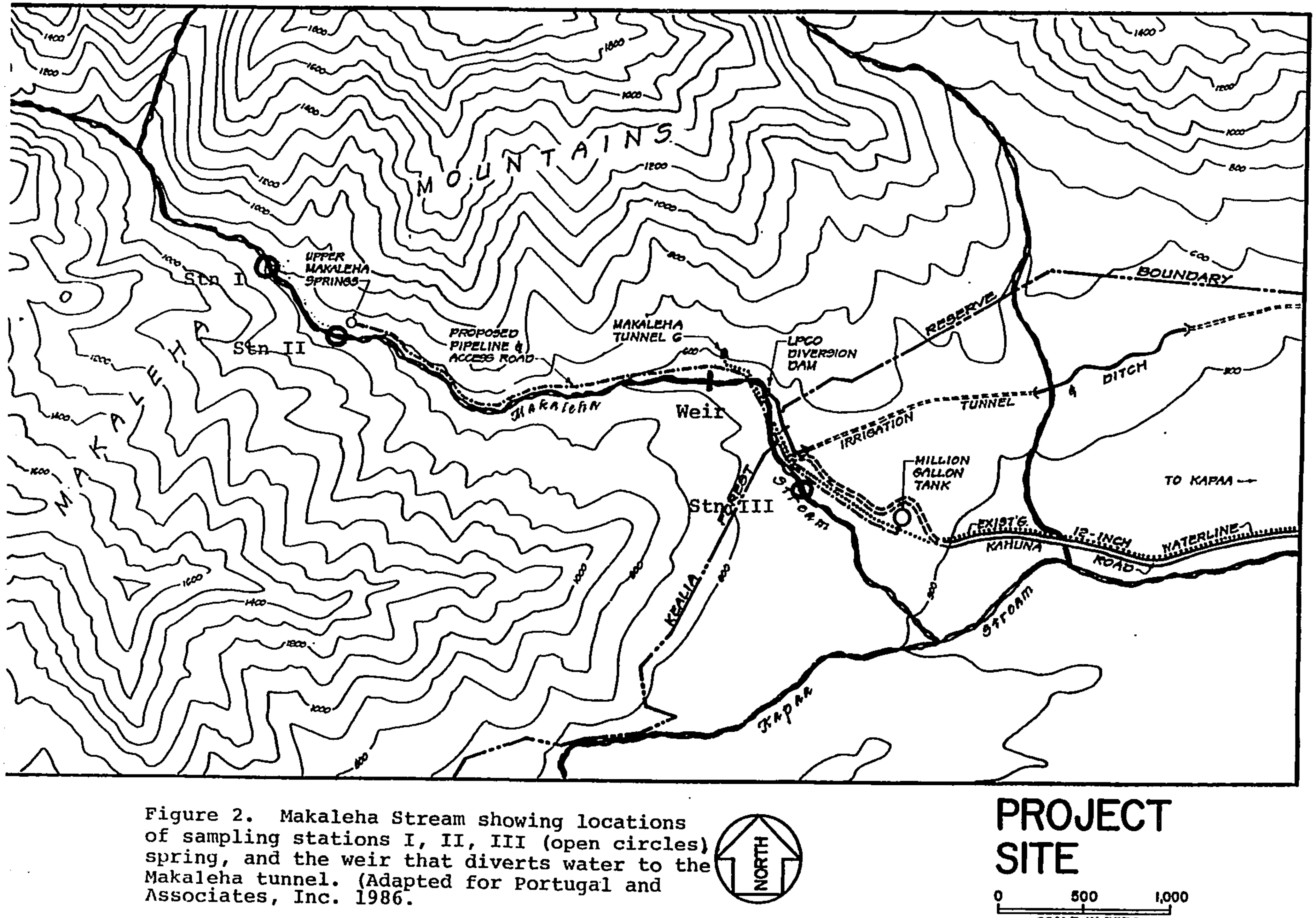

Figure 2. Makaleha Stream showing locations of sampling stations I, II, III (open circles) spring, and the weir that diverts water to the Makaleha tunnel. (Adapted for Portugal and Associates, Inc. 1986.

square for each species.

2.2.2 Aquatic macrobenthic animals. The benthic population was obtained with a WILDCO Surber Stream Bottom Sampler which had a frame of 30 cm x 30 cm (12" x 12") and a net mesh size of 728 microns. The procedure required the seating of the lower frame of the sampler, stirring the bottom and gently wiping the pebbles and stones within the frame so that any animal life will float up and drift to the net. All the contents of the net were placed in plastic whirl-paks, preserved in 70 per cent denatured ethyl alcohol and brought to the laboratory where they were sorted, identified, and counted.

Samples were taken in riffles with gravel bottoms at between 30 and 60 cm (12" and 24") water depth.

2.2.3 Riparian vegetation. For the purposes of this study, an estimate of relative cover and abundance for each species was adapted from Elliot and Hall (1977) as shown in Table 1. Most scientific names are from Neal (1965).

Table 1. Vegetative coding system used in categorizing riparian vegetation (from Elliot and Hall 1977).

COVER	ABUNDANCE
< 5% = 1	rare (1 - 4 plants) = R
5% - 25% = 2	occasional (5 - 14 plants) = O
26% - 50% = 3	frequent (15 - 29 plants) = F
51% - 75% = 4	abundant (30 - 99 plants) = A
76% - 100% = 5	very abundant (> 100 plants) = V

The area sampled was confined horizontally (i.e. across the stream) to within 3 meters of the waters edge and vertically (i.e. upstream - downstream) to within 10 meters on either side of the center of the sample station. Vegetation beyond this area was noted only if: 1/ the canopy of the stream was involved and 2/ if interesting native plants were observed.

As significant physical differences may exist between the right and left banks of a stream, each was treated separately (note: left and right was always determined looking upstream). A riparian vegetation list was therefore compiled separately for each bank and generally plants are listed beginning with plants closest to the waters' edge. An asterisk (*) after a species indicates a tree species involved in creating the canopy over the stream channel.

The vegetative cover of the stream (canopy) affects the amount of sunlight reaching its surface. This may be another important factor in the overall energy production of the ecosystem. The canopy was estimated as % shaded. A 100% shaded condition indicates that the canopy completely covered the stream channel, 50% shaded indicates that the canopy covered half the stream channel, and so on.

2.3 Physicochemical Features

2.3.1 Channel width, depth, and flow velocity. Channel width was obtained by stretching a 100-ft tape across the channel. Depth was measured from one bank to the other at foot intervals at the upper two stations and at three-foot intervals at the lower two stations using the calibrated Swoffer flow meter model 2100 rod. Flow velocity was measured with the Swoffer flow meter for depth. Flow values obtained are from 0.6 of depth. The flow meter is accurate to within 1% and precision is a standard deviation of plus or minus 0.01 ft/s.

2.3.2 Discharge. Discharge was derived from the width, depth, length, and flow velocity data using the Reid (1961) equation: Q(cfs) = WDV, where W is channel width in feet, D is the mean channel depth in feet, and V is mean velocity in feet.

2.3.3. Longitudinal gradient. The data for this parameter was obtained by measuring the stream length from USGS topographic maps using a map measurer. Elevations were also obtained from the same topographic maps.

2.3.4 Substrate. The substrate of each of the sampling station was determined by above water visual examination. The substrate was sketched, photographed and quantified using a modified system adapted from the Wentworth classification of particle size (table 2). The plant cover of exposed and submerged substrate was also estimated as it may be an important habitat component affecting species composition and abundance.

Table 2. Substrate coding system (modified Wentworth: Bovee and Cochnauer 1977) used in characterizing the substrate.

Substrate	Particle size, range (mm)
1. Bedrock	solid, lava slab
2. Exposed boulder	250 - 4,000 mm (10 in.-13 ft)
3. Submerged boulder	same as above
4. Cobble	65 - 250 mm (2.6 in.-10 in.)
5. Gravel	5 - 65 mm (0.2 in.-2.6 in.)
6. Sand	1 - 5 mm (0.04 - 0.2 in.)
7. Silt	1 mm (0.04 in.)

2.3.5 Water temperature. An alcohol thermometer was used for these data. Water temperature was cross checked with the oxygen meter and conductivity meter. These meters are also equipped to measure water temperature.

2.3.6 Conductance. Water conductivity was measured with a YSI model 33 meter at subsurface in the same place where dissolved oxygen was measured. The meter has an accuracy of plus or minus 2.5% maximum error. Conductivity is expressed in micromhos/centimeter (umhos/cm).

2.3.7 Dissolved oxygen. This was measured with a YSI 57 dissolved oxygen meter at subsurface from an area representative of the sampling station. The meter measured oxygen in mg/L. The data were converted to per cent saturation. The meter accuracy is given at 0.1 mg/L.

2.3.8 pH. This feature was measured with a Digisense pH meter model 5994 (Cole-Parmer Instrument Co.) at subsurface level at the same place where dissolved oxygen and conductance were measured. The accuracy for this meter is 0.01 pH unit. The meter was calibrated at each sampling site in accordance with the procedure manual.

2.3.9 Turbidity. A Hach Portalab Turbidimeter model 16800 was used to measure turbidity. Accuracy is plus or minus 5% of full scale.

3. RESULTS AND DISCUSSION

3.1 Biological Features

3.1.1 Aquatic macrofauna. Table 3 lists the macrofauna in Makaleha stream. It includes their common and/or local names, origin, and listing in scientific and/or official register.

Table 3. List of macrofauna in Makaleha Stream, Kauai (March - April 1990).

Scientific Names	Common Names	Origin	Listing
Annelida			
Oligochaeta	earthworm	unknown	none
Insects			
Diptera:			
Chironomidae	midge larvae		
1. <u>Orthocladius grimshawi</u>		alien(?)	none
2. <u>Calepsectra hawaiiensis</u>		endemic	none
Culcidae	mosquito larvae	alien(?)	none
Tipulidae	cranefly larvae	endemic	none
Trichoptera	caddisfly larvae		
1. <u>Cheumatopsyche analis</u>	caddisfly	alien	none
2. <u>Oxyethira maya</u>	microcaddisfly	alien	none
Coleoptera			
Staphylinidae	rove beetles	unknown	none
Odonata: Zygoptera			

Megalagrion sp..	damselfly naiad	endemic	none
Crustacea			
Decapoda			
1. *Atyoida bisulcata*	'opae-kala'ole (mountain shrimp)	endemic	none
Fishes			
1. *Awaous stamineus*	'o'opu-nakea	endemic	special concern (Deacon et al. 1979) depleted (Miller 1972)
2. *Lentipes concolor*	'o'opu-alamo'o	endemic	threatened (Deacon, et al. 1979). Depleted (Miller 1972)
3. *Poecilia reticulata*	wild guppy	alien	none
Amphibia			
1. *Rana rugosa* tadpoles	wrinkled frog	alien	none

Terms used:

Alien = brought to Hawaii either intentionally or accidentally by man.

Depleted = indicates that the organism is still found in numbers adequate for survival but has been heavily depleted and continues to decline substantially (Miller 1972).

Endangered = one which is in danger of extinction throughout all or a significant portion of its range (Deacon et al. 1979).

Endemic = found in nature only in Hawaii.

Special concern = are those species that could become threatened or endangered by relatively minor disturbances to their habitat or that require additional information to determine their survival (Deacon et al. 1979).

Threatened = facing extinction, needs special protective measures.

Fourteen animal species were found in Makaleha Stream. They include 8 insects, 3 fish, 1 crustacea, 1 amphibia, and 1 annelida. Of the 14, 11 species are endemic to Hawaii. Two of these endemic ('opae-kala'ole, 'o'opu-nakea) are of some economic importance.

Two endemic species are listed in scientific publications as THREATENED. The goby fish ('o'opu-nakea) is listed OF SPECIAL CONCERN by Deacon, et al. (1979) and depleted by Miller (1972) but has no legal protection (Johnson 1987). The second, also a goby fish ('o'opu-alamo'o), is listed OF SPECIAL CONCERN by Deacon, et al. (1979) and like the preceding species, has no legal protection (Johnson 1987, USFWS 1989). It has been recommended for endangered status by the Honolulu Office of the USFWS (Ford 1990 personal communication). (For definition of DEPLETED, see footnote in table 3, above. Miller's DEPLETED is about equivalent to Deacon, et al.'s OF SPECIAL CONCERN.).

Six in the list are alien species. The wild guppy was introduced to Hawaii for mosquito control. The insect species are known to serve as food for the larger aquatic animals (e.g. 'o'opu-nakea). One species is of unknown origin.

The endemic goby 'o'opu-alamo'o (and probably all the gobies in the species inventory) is diadromous, a designation for species which are migratory between fresh and salt water. The life history of this species can be generalized as follows: spawning may occur over a period of months (July-December), in the lower reaches of the streams. Hatchlings are carried to the sea by stream flow where they grow and develop over a period of between four and seven months as plankton (Ego 1956. Tomihama 1972, Kinzie and Ford 1982. Radtke. Kinzie and Folsom 1988). The larvae then metamorphose into post-larvae known as **hinana** near the mouths of streams, settle on appropriate substrata, and migrate upstream to their places of permanent residence. This life style requires an unimpeded passageway from the stream mouth to the upper elevations.

3.1.2 Distribution and relative abundances. The occurrence and relative abundances of the fish, crustacea, annelida, and amphibia are shown in Table 4.

Table 4. Distribution and relative abundances of crustaceans, fishes and amphibia in Makaleha stream, Kauai (March-April 1990).

Scientific Name (Common Name)	Sampling Station I	II	III
A. Crustacea			
<u>Atyoida bisulcata</u> * (`opae-kala`ole)	0	0	0
B. Fishes			
<u>Awaous stamineus</u> (`o`opu-nakea)	+	++	+++
<u>Lentipes concolor</u> (`o`opu-alamo`o)	+	+	+
<u>Poecilia reticulata</u> (wild guppy)	0	0	+++
C. Amphibia			
<u>Rana rugosa</u> * (wrinkled frog)	0	0	0

Legend: +++ = abundant (6 - 10)
++ = common (2 - 5)
+ = uncommon (1)
0 = not collected or seen, possibly absent.

* Indicates that these were found in Makaleha but not in the designated sampling stations. Both of these species were found in the very high elevations at Makaleha.

3.1.3.1 Crustacea and amphibia. The `opae-kala`ole, <u>Atyoida bisulcata</u>, was not found in the designated stations but in the very high elevations as already explained. At the time of our survey, the collecting stations were one degree Celsius colder than the upper elevations. This is due to the open canopy at the elevations where the Atyids were found.

The <u>Rana rugosa</u> tadpoles were also found in the warmer water in shallow pools nearest the stream bank outside of the designated stations. They were found in higher elevations than our highest sampling station (I).

3.1.3.2 Fishes. Three fish species were collected. Two are endemic to Hawaii (found only in Hawaii and nowhere else) and both are true gobies (with fused pelvic fins to form a suction disc). Both of these species are listed in scientific publications as "threatened." This designation, however, do not have official standing and therefore are not under federal government protection. These were found in all three stations at Makaleha. There are more nakea than alamo'o. Based on size classification, the alamo'o living at Makaleha are adults. In the 1986 study, the same situation was also true. Based on these two short-time study, it appears that the alamo'o are captive population, meaning there is no recruitment.

The nakea supports a small commercial and recreational fishery on Kauai with Hanalei and Wainiha rivers as the prime fishing areas. The last time it was sold in the markets, two years ago, it was $10.00 a pound. This is the largest of the endemic gobies, reaching a minimum of over 30 cm standard length in Kauai streams. It is well known for its downstream migrations usually in association with freshets or flash floods. Spawning occurs near the mouth of rivers and streams. The best published information on this goby is Ego (1956) but there are extensive on-going studies on the nakea by University of Hawaii (Robert Kinzie), Kauai Community College (Mike Kido) and Department of Land and Natural Resources (Don Heacock) scientists.

The alamo'o has no commercial value at present. In old Hawaii, the alamo'o was considered "a sign of bad luck to find one in a net when fishing for other fish" (Titcomb, 1972, p. 127). It is, however, listed as "threatened" in scientific publications and have been recommended for the endangered list by the USFWS unit in Honolulu. A description of this species is found in the 1986 draft EIS for this project (Timbol 1986). The life history of the alamo'o has not been studied but several authors (e.g. Lau 1973, Maciolek 1977, Timbol, et al. 1980, Kinzie and Ford 1982) imply that this species is diadromous. On the other hand, Nishimoto and Fitzimmons 1986, pp. 184-185), the alamo'o "probably has no spawning migration but rather spawns throughout the length of a stream."

The absence of a certain species in a stream could be as significant as its presence. For the Makaleha, we have not found the 'o'opu-nopili (Sicyopterus stimpsoni), an endemic and a true goby. It was absent in 1986 and is still absent in 1990. This species has been recommended by Timbol and Maciolek (1978) as an indicator species. Its decline in population density, or in extreme case, its disappearance in a stream is a good indication of serious degradation. Extensive information on the biology of the nopili is available in Tomihama (1972) and Yuen (1986).

The other fish species, the wild guppy (Poecilia reticulata), was introduced to Hawaii to help control the mosquito population. It thrives in shallow, slow flowing and warmer water. Its presence in Makaleha also indicates less than pristine quality of the stream. In contrast, this poeciliid has not been collected in Wainiha River despite of a year-long, monthly collected there (Timbol 1989b).

3.1.3.3 Aquatic macrobenthic animals. Nine species of macrobenthos were found living in or around the stream substrate. Their distribution and relative abundances are in Table 5. Eight of these are aquatic insects or semi-aquatic insects. The ninth is an earthworm. The most important components of the insect population are the chironomids and caddisflies larvae. These form the major food source of the fish and large crustacean population in the stream.

Table 5. Distribution and relative abundances of aquatic macrobenthic animals in Makaleha stream, Kauai (March -April 1990).

Scientific Name (Common Name)	Sampling Station I	II	III
A. Annelida			
Oligochaeta	O	+	O
A. INSECTS			
I. Diptera (Flies)			
1. Orthocladius grimshawi	++	O	++
2. Calepsectra hawaiiensis (midge larva)	++	O	++
Culcidae (mosquito larva)	O	+	++
Tipulidae (cranefly larvae)	+	O	O
II. Trichoptera (caddisflies)			
1. Cheumatopsyche analis (caddislfy larva)	+ +	+	++
2. Oxyethira maya (microcaddisfly larva)	+	+	+
III. Coleoptera (beetles)			
1. Staphylinidae (rove beetle)	++	O	O
IV. Odonata			
Zygoptera (Damselfly) Megalagrion sp. (damselfly naiad)	O	+	O

Legend: +++ = abundant (6-10)

++ = common (2-5
+ = uncommon (1)
O = not collected, possibly
absent

Two insect species are found in all four stations: the _Cheumatopsyche analis_ (caddisfly larva), _Oxyethira maya_ (microcaddisfly). On the basis of abundance the caddisflies are more numerous than the microcaddisflies. It appears that in Makaleha, these Trichoptera larvae form the bulk of food for the gobies.

Station III harbors the most species of insect, six out of eight. Both stations I and II each has five species. However, the species at station II which is in the immediate vicinity of the spring proposed for development has unusual macrobenthic biota. This is where damselfly naiad and earthworm were collected. These two species are not in the two other stations. In addition, station II has no midgefly larvae, a unique situation for a stream in Hawaii since the midgefly larva usually are the most numerous in terms of numbers.

3.1.3 Riparian vegetation

Riparian vegetation (i.e. vegetation alongside a stream or river) may be an important source of energy input for lotic (flowing-water) ecosystems. Allochthonous material has been shown to play a significant role in energy input for woodland streams in temperate climate (Minshall 1967, Fisher and Likens 1973). However, whether or not this is also true for Hawaiian streams has yet to be studied.

The stream channel appears to be highly colonized by non-native plants as evidenced by the common presence of yellow guava (_Psidium guajava_), the hau bush (_Hibiscus tiliaceus_), banana (_Musa paradisiaca_), and weedy species like honohono-kukui (_Oplismenus hirtellus_).

Perhaps the most significant impact of alien plants on the stream itself is in the extensive canopy created by tree species. The channel is shaded throughout most of its length significantly reducing sunlight reaching the water's surface. Yellow guava (_Psidium guajava_) is the most common component of the riparian canopy although the hau bush (_Hibiscus tiliaceus_) and the rose apple (_Syzygium jambos_) contribute to the canopy in lower portions of the stream.

In one fairly long section of stream above station III up to Station II, the hau bush (_Hibiscus tiliaceus_) has completely overgrown the channel. The dense root mats in the stream created by such a condition may block the upstream migration of diadromous species like the goby fishes ('o'opu). An introduced species, wild bamboo (Schizostachyum glaucifolium), located on the left bank between station III and station II contribute to the considerable shading of a significant portion of the stream channel.

Despite the common presence of introduced plants, significant patches of native vegetation. The native fiber plant olona (Touchardia latifolia) was observed upstream from the higher elevation station I.

The streamside vegetation is highly susceptible to high water during flood. It is not uncommon therefore to see the vegetation laid down and strands of loose vegetation hanging incredibly high on the banks. Riparian vegetation is therefore constantly in a state of flux and only very hardy species can survive for any length of time alongside the stream. This may be one factor which clears the way for hardy species like yellow guava (Psidium guajava) and other introduced tree-like plants which now dominate the water's edge. A more comprehensive work on the vegetation of the Makaleha watershed can be found in Linney and Char (1986).

The riparian vegetation and vegetative canopy over stream channel is summarized in the following table 6.

Table 6. Riparian vegetation in sampling stations at Makaleha stream, Kauai (March - April 1990).

STATION I: Upper station

Canopy - 50% shaded

	Coverage	Abundance
left bank		
uluhe fern (Dicranopterus linearis)	1	R
tree fern (Cibotium sp.)	2	R
'ama'u fern (Sadleria sp.)	4	A
lantana (Lantana camara)	4	A
yellow guava * (Psidium guajava)	4	A

right bank

fishtail fern (<u>Nephrolepis biserrata</u>)	2	O
juvenile 'ama'u fern (<u>Sadleria sp</u>.)	5	V
hau bush * (<u>Hibiscus tiliaceus</u>)	5	V
yellow guava * (<u>Psidium guajava</u>)	5	V
ti leaf (<u>Cordylina terminalis</u>)	2	O
'ie'ie (<u>Freycinetia arborea</u>)	1	R

<u>STATION II: Spring station</u>

Canopy - 40% shaded

	Coverage	Abundance
left bank		
laua'e fern (<u>Microsorium scolopendria</u>)	4	V
ohia-lehua (<u>Metrosideros polymorpha</u>)	5	V
honohono-kukui (<u>Oplismenus hirtelus</u>)	5	V
yellow guava * (<u>Psidium guajava</u>)	5	F
hau bush * (<u>Hibiscus tiliaceus</u>)	1	R
right bank		
night cestrum (<u>Cestrum noctornum</u>)	1	R
taro (<u>Colocasia esculenta</u>)	1	R
wild ginger (<u>Zingiber zerumbet</u>)	2	F
yellow guava * (<u>Psidium guajava</u>)	5	F
mountain apple (<u>Syzygium malaccensis</u>)	3	O
banana (<u>Musa paradisiaca</u>)	2	O
'ohi'a-lehua (<u>Metrosideros polymorpha</u>)	1	R
hau bush * (<u>Hibiscus tiliaceus</u>)	2	O

STATION III: Weir station

Canopy - 100% shaded

	Coverage	Abundance
left bank		
wild bamboo * (Schizostachyum glaucifolium)	5	V
Wedelia trilobata	2	O
yellow guava * (Psidium guajava)	1	R
hau bush (Hibiscus tiliaceus)	3	F
rose apple (Syzygium jambos)	4	A
right bank		
Wedelia trilobata	2	O
hau bush (Hibiscus tiliaceus)	5	V
yellow ginger (Hedychium flavescens)	4	V
yellow guava (Psidium guajava)	3	F

Legend: R = rare
O = occasional
F = frequent
A = abundant
V = very abundant

3.2 Physicochemical

Sampling was done under "rainy" conditions. It took two days to do the field work for these data.

3.2.1 Channel width, depth, and flow velocity.

Makaleha stream is characterized by narrow stream channels in the upper elevations, from 5 to 10 feet width, widens at mid elevations (15 feet) and is widest at the lowest elevation. It is shallow, only 0.4 ft at the upper elevations, becoming a foot deep at mid elevations and a little bit more than two feet at the lowest elevation. Its flow velocity is faster at the upper elevation (1.8 ft/s), slowing to a third of its original velocity at mid elevations down to one-sixth at the lowest elevation.

Makaleha Stream is subject to strong freshets that more than doubles the depth, width and velocity. For example, on April 8, Station II (in the vicinity of the spring, almost doubled in width (from 24 ft to 40 ft) in less than an hour. We obtained 12 measurements at subsurface flow velocities (the only one we could take safely) in one at one location at two feet from the bank. Flow velocities thus obtained ranged from a low 6.00 to a high 7.91 ft/sec (mean 6.97).

The data obtained is summarized in the table that follows (table 7).

Table 7. Width, depth and flow velocity in Makaleha Stream and Spring, Kauai. (March - April 1990)

	Parameters		
Stations	Width (ft)	Depth (ft) mean (range)	Flow Velocity (ft/s) mean (range)
I	23	1.2 (0.6-2.3)	1.60 (1.14-2.21)
II	25	1.2 (0.3-1.3)	1.95 (0.14-4.57)
III	14	1.9 (0.8-2.1)	2.46 (0.75-3.33)
Spring			
Outlet A	1.5	0.35	1.75 (1.68-1.86)
Outlet B	5.0	0.55 (0.07-0.88)	0.24 (0.04-1.81)

3.2.2 Discharge at the Makaleha Stream and Spring

Discharge is the total volume of stream water passing a point in a given period of time. Discharge data for Makaleha Stream come from one measurement only. They should be considered preliminary. The values, however, permit comparison between stations. The discharge at each sampling station are in Table 8.

Table 8. Discharge at Makaleha Stream and Spring, Kauai, March 29 and 30, 1990.

Station	Mean Q (cfs)	Range (cfs)
I	44.2	15.7 - 116.9
II	58.5	1.1 - 148.5
III	65.4	8.4 - 97.9
Spring		
Outlet A	0.92	0.88 - 0.98
Outlet B	0.66	0.01 - 7.96
Total Spring	1.58	0.89 - 8.94

Discharge at Makaleha shows an increase in a downstream direction (Station 1 down through Station III) . This indicates that there are tributaries that add to the mainstream. Between stations I and II, there is an increase of about 14.3 cfs, most of it comes from a small waterfall coming from the left bank (Figure 3 and Appendix A).. Between stations II and III, the increase is less than half (6.9 cfs), the increase coming mainly from at least two permanent seepages on the left bank which trickle into the mainstream Pictures of these seepages (intermittents 1 and 2) are in Appendix A. THE INCREASE IN DISCHARGE OF ABOUT 6.9 CFS INCLUDES THE 1.6 CFS FROM THE SPRING. Without the water contributed by the spring, the increase in discharge between Stations II and III is about 5.3 cfs.

Overall, the surface flow at the main channel between Stations II and III will be about 60.1 cfs (65.4 - 5.3). Looking at it another way, the discharge of the spring comprise about 8% of the total. This estimate is much lower than that given in the draft EIS (one-sixth of Makaleha Streams total, Portugal and Associates, Inc. 1986 p. 10) which is about 17%. It should be noted that both this study and the Portugal figure are based on limited data and should be considered preliminary.

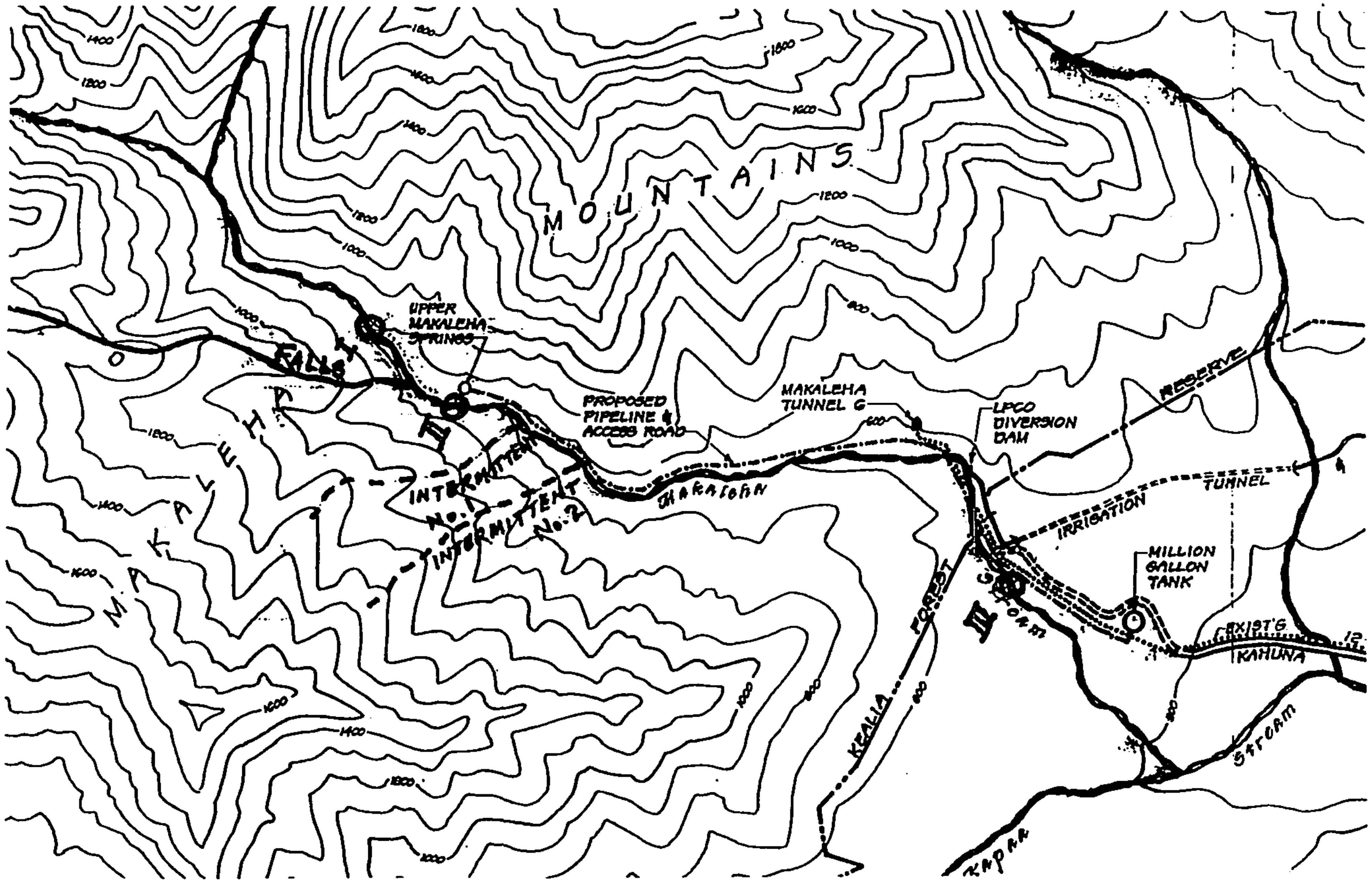

Figure 3. Makaleha Stream showing the main sources for additional surface flow between Stn I and II (falls) and between II and III (two intermittents).

3.2.3 Longitudinal gradient.

The gradient of a stream is the slope of its longitudinal course and is expressed as vertical descent per unit of horizontal distance (Reid 1961). Generally the headwaters exhibit a steep slope, while the lower elevations exhibit a more gentle slope. Figure 4 shows the longitudinal gradient for the Kapaa-Makaleha mainstream channel. Its source is at 1800 ft. From its source to the ocean, the water travels 48576 ft (9.2 miles). The gradient is only 3.7%. Compared with the three major rivers on Kauai, the Kapaa-Makaleha system is gentler (Wainiha 7.6%, South Fork Wailua 5.6%, Hanalei 5.4%; Timbol 1977). However, if only Makaleha Stream is taken into consideration, the gradient is a very steep 29%.

Longitudinal gradient affects flow velocity. Other things being equal, the steeper the gradient, the higher the flow velocity.

3.2;4 Substratum.

The substratum is an important physical parameter of lotic ecosystems. In Hawaii, the substrate is characterized by solid lava bedrock, varying sizes of exposed or submerged weathered basalt particles, plant detritus, organic material, and varying degrees of vegetation covering the substratum. Substrate composition has important biological implications because it determines available aquatic habitat and affects physicochemical parameters such as dissolved oxygen.

Slope is an important determinant of substrate type as affects the velocities of stream flows and the resultant scarification of the streambed. Makaleha descends from an elevation of approximately 1800 feet, travels 1.8 miles before it enters Kapaa Stream. From the Kapaa-Makaleha junction, water flows another seven miles plus to sea level (Fig. 4). High velocities are evidenced at higher elevations in the narrowness of the channel and the predominance of bedrock. High channel velocities may also be a factor in the low abundance of algae observed on the substrate throughout the stream system.

As in any lotic system in Hawaii it should be noted that substrate parameters especially in the lower portions of the stream where velocities are amplified, are highly variable and subject to drastic change during periods of flood.

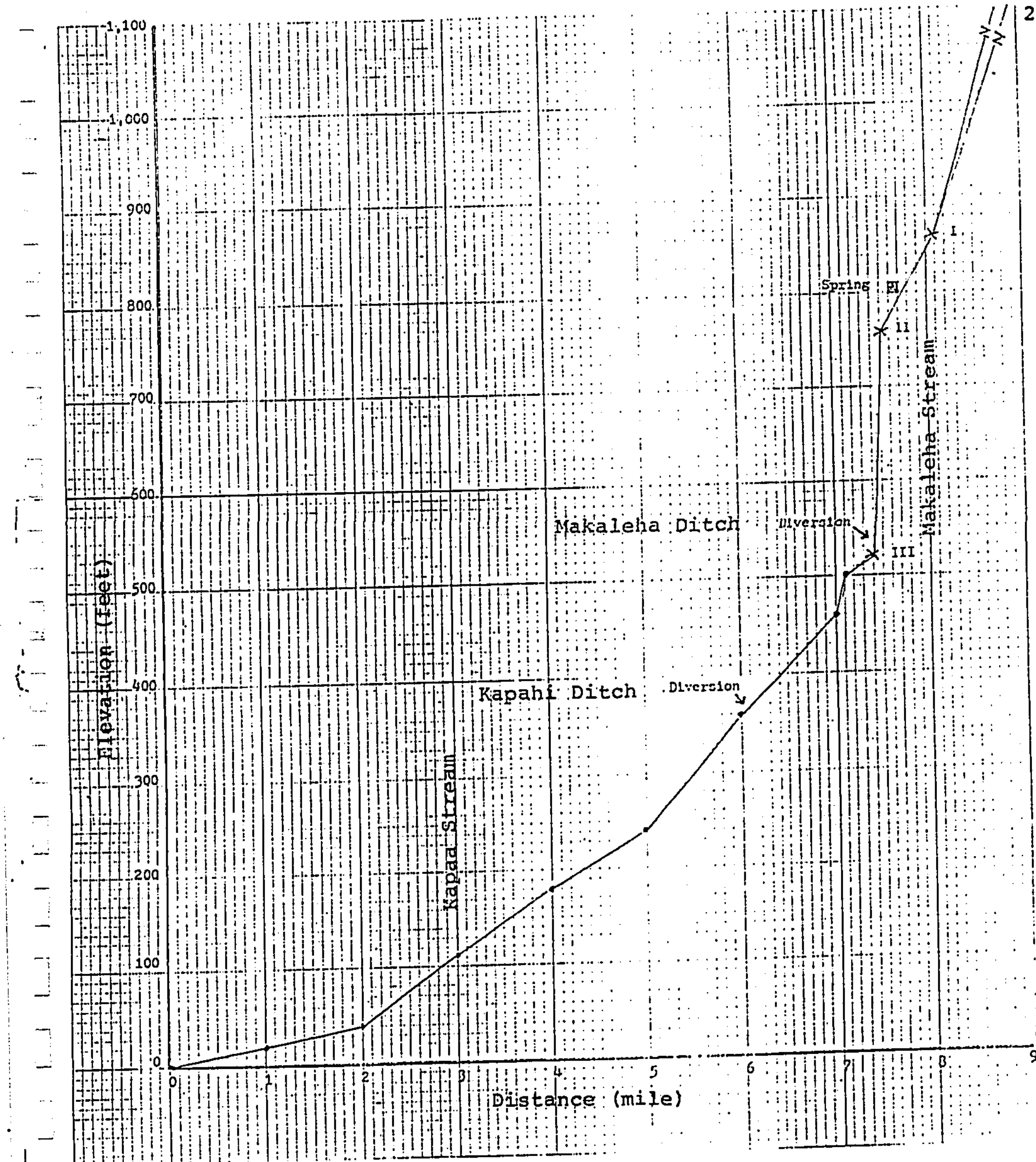

Figure 4. Longitudinal gradient of the Makaleha-Kapaa stream system (3.7%). Makaleha Stream alone has a steeper gradient (29%). This also shows existing diversion weirs. The proposed development is marked "spring."

Table 9. Substrate in the three sampling stations at Makaleha stream, Kauai (Wentworth scale: Bovee and Cochnauer 1977).

Station I: Upper station, elevation 750 ft

Substrate	% Coverage
1/bedrock	30
2/ exposed boulder	30
3/ submerged boulder	20
4/ cobble	10
5/ gravel	10
6/ sand	0
7/ silt	0

Station II: Spring station, 690 ft

Substrate	% Coverage
1/ bedrock	30
2/ exposed boulder	20
3/ submerged boulder	15
4/ cobble	20
5/ gravel	10
6/ sand	5
7/ silt	0

Station III: Weir station, 500 ft

Substrate	% Coverage
1/ bedrock	30
2/ exposed boulder	20
3/ submerged boulder	10
4/ cobble	20
5/ gravel	10

6/ sand	10
7/ silt	0

Makaleha stream, using the sampling stations as representative of the entire stream, shows a substrate of bedrock and boulder. At the high elevations, there is no sand and silt, a minimum of sand at middle elevation and some sand and silt at the lower elevations. That the mean particle size decreases in a downstream direction is normal for streams (Hynes 1970).

3.2.5 Temperature, conductance, dissolved oxygen, pH, and turbidity

These short-term data reflect only the conditions at the time of sampling. They may be useful for comparative purposes only. Since Makaleha stream has not been studied for conductance, dissolved oxygen, and pH, these first time data will be valuable as the "before springs development" if the planned development takes place. Future studies could use these for baseline data. These data are summarized in Table 10.

Subsurface water temperature is between 15 and 17 degrees Celsius with the uppermost station I two degrees cooler than the lower station III. This range is well within the range of unaltered stream in Hawaii (Timbol and Maciolek 1978) and within the living (tolerance) limit of native gobies (Hathaway 1978).

Conductance indicates total dissolved solids in water (Cole 1979). Results show a very low conductance, ranging from a low 40 microhms (umhos) at the upper station I, gradually increasing with decreasing elevation to 57 at the lowest station III. These values are much lower than those for Kauai streams which have farms within their drainage areas (ave. 131 umhos, Timbol and Maciolek 1978). On the other hand, conductance for Makaleha Stream compares favorably with those obtained at Limahuli Stream (51 through 71 umhos, Timbol 1989a) and the much larger Wainiha River (53 through 83 umhos, Timbol 1989b).

The pH is from slightly acidic in all three stations studied. This is well within the range of slightly acidic to slightly alkaline water for normal Hawaiian streams. This condition comes from organic acids from decomposing plant materials in the watershed which tend to make stream water acidic but is neutralized as the water flows over volcanic rock.

Dissolved oxygen was measured as mg/L and converted to per cent saturation. Makaleha stream water is oxygen saturated, from the upper elevations down to the lowest elevation. Considering the low water temperature, the oxygen available for the aquatic animals is considerable, from 9.60 to 10.00 mg/L (actual values obtained). These indicate clean, high velocity, bubbling water.

Turbidity measures an optical property of the water sample which results from the scattering and absorbing of light by particulate matter present. There is no direct relationship between turbidity as read by the instrument and the weight concentration of the matter present. Makaleha Stream turbidity of 2.5 to 2.6 NTU is a little higher than what is expected reflecting the rainy condition during the field work. When it has not been raining, turbidity was only about 1.0 NTU (unpublished data).

Table 10. Summary of water temperature, conductance, dissolved oxygen, pH, and turbidity obtained in Makaleha stream, Kauai (March - April 1990).

Physicochemical Parameters	Sampling Stations I	II	III
Water temperature (degree Celsius)	15	15	17
Conductance (umhos/cm)	40	40	57
pH	6.82	6.08	6.82
Dissolved oxygen (per cent saturation)	95	99	99
Turbidity (NTU)	2.6	2.5	2.5

4. SUMMARY

4.1 Biological

4.1.1 Fish, crustacea, and amphibia

Three fish species and one crustacean species were found in Makaleha Stream. Of the three fish species, the poeciliid P. reticulata is the more abundant by numbers. The other two species are both endemic: the 'o'opu-nakea (A. stamineus) is the more common and is found in all sizes. The 'o'opu-alamo'o (L. concolor) is represented only with adult individuals and as expected, they are not as abundant as the nakea. Both of these species are listed as NEEDING PROTECTION but have no legal protection. The A. stamineus ('o'opu-nakea) supports a small ethnic fishery on Kauai.

The endemic decapod crustacean, 'opae-kala'ole (A. bisulcata) is harvested for home consumption. However, in Makaleha, these are represented in very small numbers and are found only in the elevations higher than the sampling stations.

The wrinkled frog, Rana rugosa, is ubiquitous in Hawaiian streams especially where the water is warm.

4.1.2 Insect larvae and other benthic organism

The macrobenthic residents consist of at least nine species; one annelid and eight insects. It must be noted that the insect population in Makaleha are low in numbers. The highest are only common (2-5 per square foot) as compared with Limahuli Stream where they are very abundant (> 10 per square foot, Timbol 1989a). The caddisflies larvae are found in all three stations sampled and in Makaleha, they form the bulk of available for the fishes.

4.1.3 Riparian vegetation

The riparian vegetation is dominantly alien contributing significantly to the vegetative canopy over the stream channel. These are the ubiquitous yellow guava, and in lower elevations, the hau bush and rose apple trees mingle with the dominant guava.

4.2. Physicochemical Features

4.2.1 Width, depth, flow velocity

Makaleha Stream as represented by sampling stations is about 25 feet wide at the high elevations and narrower by 10 feet at the lower elevation due to channelization at the lower elevation. It is about 1.2 feet in depth at the higher elevation but deepens downstream, again an effect of channelization. The flow velocity is about 1.60 ft/s at the upper elevation, gathers momentum as it flows downstream to 1.95 at station II and still faster to 2.46 at the lower Station III.

4.2.2 Discharge

Based on one time measurement, the discharge at the upper elevation is about 44 cfs, increases at mid-elevation to 59 and further increases up 65 cfs. The spring which is at mid-elevation contributes 1.6 cfs to the stream or about 8% of the total.

4.2.3 Longitudinal gradient

From source to the ocean, the Makaleha-Kapaa stream system has a average 3.7% gradient. For Makaleha Stream only, the gradient is a steep 29%.

4.2.4 Substrata

The substrate at Makaleha consists mostly of bedrock and boulder at all elevations. The lower elevation station has also considerable cobble.

5. CONCLUSION AND RECOMMENDATIONS

5.1 The 'o'opu-nakea will survive the development, the 'o'opu-alamo'o and the 'opae-kala'ole may not survive where there will be dewatering but the present populations upstream of the development may survive.

Makaleha Stream on the east side of Kauai is small if compared with the well known Kauai streams such as Wailua, Hanalei and Wainiha. Like its larger counterparts, its substrate consists of lava bedrock and large boulders at high elevations and boulder, cobble. and gravel at low elevations. It's water is cold, has low conductance, slightly acidic and oxygen saturated.

Makaleha Stream has unique characteristics. Its flow is totally exported from its channel during low flows by a tunnel (Makaleha Ditch) at 580 feet elevation just before it joins the Kapaa mainstream. Again, at 360 feet elevation, the Kapahi ditch drains all surface flow from the Kapaa mainstream channel at low flows. Despite of these double dewatering, Makaleha Stream harbors endemic fish and prawns, one of which (A. stamineus) is definitely diadromous, the two (prawn A. bisulcata, fish S. stimpsoni) may also be diadromous but there is a question whether that condition is obligatory (Couret, personal communication; Nishimoto and Fitzsimmons 1986).

The Water Department of Kauai County is proposing to tap the springs for domestic use. Although not similar to the first two diversions, this proposal also will decrease the mainstream surface flow. Assuming that all of the surface flow coming from the spring does not add to the mainstream flow, the decrease will be between 8 and 17% (this study for the lower value; Portugal and Associates 1986 for the latter).

An analysis of the sizes of these animals based on the residents in the three sampling stations indicate that the A. stamineus consists of all sizes. This indicates that despite of the two diversion weirs and the consequent dewatering, the post-larvae (hinana) are still able to overcome the obstacles on their way to Makaleha. On the other hand, the absence of small (post-larvae, juveniles) L. concolor, indicates that the fish living at Makaleha may be a "captive population." For one reason or another, the L. concolor post-larvae migrating from the lower elevations do not survive the same obstacles. The prawn A. bisulcata, may or may not be recruiting from outside. We do not have enough data to even risk an educated guess whether this species could overcome the present barriers to their migration.

The main interest in this study is to assemble physicochemical and biological data upon which to base an educated guess regarding the continued survival of the three endemic inhabitants at Makaleha. Since the physicochemical features of Makaleha Stream (only) compare favorably with those of Limahuli Stream, a comparatively pristine stream on the northshore of Kauai, which supports a healthy complement of native aquatic fauna, Makaleha stream could also continue to support the endemic aquatic fauna that is now living there.

The proposed dewatering due to spring development will degrade the physicochemical parameters but the extent of degradation is not now known. For sure, the 'o'opu-nakea (A. stamineus) will survive since this species is found even in highly degraded streams such as the Huleia Stream. The continued survival of the 'o'opu-alamo'o (L. concolor) at about the lower section of Makaleha Stream between the spring down to where Makaleha joins Kapaa Stream depends on the extent of dewatering and other conditions discussed next. The captive 'o'opu-alamo'o living upstream of the spring will survive since that portion of Makaleha Stream will not be affected by the proposed development. The crustacean 'opae-kala'ole population which was found upstream of the spring only, will also survive the proposed development.

Since the longitudinal gradient for Makaleha Stream is a very steep 29%, even a lowered flow between the Spring and Station III will maintain a velocity which will aerate the surface flow with adequate oxygen.

The vegetative canopy, if maintained in its present condition could buffer the expected lowered surface water flow from excessive insolation to keep water temperature within tolerance limit of the endemic fauna.

It must be emphasized that this conclusion is at best an educated guess since it is based on short-term data.

5.2 Recommendations

To minimize the potential negative effect of the proposed spring, the following are presented for consideration:

5.2.1 Minimize removal of riparian vegetation

Avoid the removal of streamside vegetation and if a considerable stretch of the stream bank must be cleared, it should be replanted as soon as possible. Riparian clearing may cause high insolation resulting in elevated water temperatures and excessive evaporation. Excessive evaporation could lead to reduced stream flow. Reduced stream flow means HIGHER WATER TEMPERATURES. Work done by Timbol and Maciolek (1978) show that stream channels without riparian vegetative canopy have higher water temperatures than stream with such canopy.

The effects of elevated temperatures can be divided into three categories: lethal, metabolic, and behavioral. Lethal temperatures make up the range within which the animal will die. Metabolic effects are "delayed effects" as in growth acceleration resulting in the inability to reach and/or pass a critical point in the animal's life cycle (Andrewartha and Birch 1954). Behavioral effects are the organism's responses to the environment.

5.2.1.1 Lethal temperatures. Laboratory studies done by Hathaway (1979) showed that the lethal temperature for adult Awaous stamineus ('o'opu-nakea) is between (first death to final death) 37.2 and 38.8 degrees centigrade with 50% (LT50) of the fish dying at 38.1 degrees centigrade. The post-larvae (hinana) are slightly more tolerant with range for mortality between 39.0 and 39.3 degrees centigrade with LT50 at 39.3 degrees centigrade. However, little is known about the effect of elevated temperature on the vitality of the postlarvae.

5.2.1.1 Behavioral effects. A motile animal will leave an area when conditions become unfavorable and will not voluntarily remain in the area until conditions become lethal. Thus, there will be a decrease in numbers as those that can leave will do so. Timbol and Maciolek (1978) found that altered (channelized) streams have higher water temperatures than unaltered ones. In the unaltered streams, native species were dominant in both number of species and biomass. Alien species were dominant in altered streams.

5.2.2 Keep maintenance roads as far away from the stream as possible.

The impact of maintenance roads comes from the resulting erosion and siltation in the streambed. Water turbidity and excessive sedimentation will alter the character of the stream. Burns (1972) reported turbidities greater than 3,000 ppm resulting from such constructions. Excessive sedimentation may alter the biological character of the stream. Fine particulate matter will become suspended in the water increasing turbidity and decreasing light penetration resulting in reduced primary productivity. Fine particles also have the effect of clogging the gills of fish which could cause suffocation. Settling of particles in rapids and riffles will reduce the natural habitats of the economically and biologically valuable endemic residents of Makaleha Stream.

Another reason for keeping the road as far away from the stream as possible is the fatal effect of gasoline, oil and other petrochemical that will drip from maintenance vehicles on the endemic aquatic fauna.

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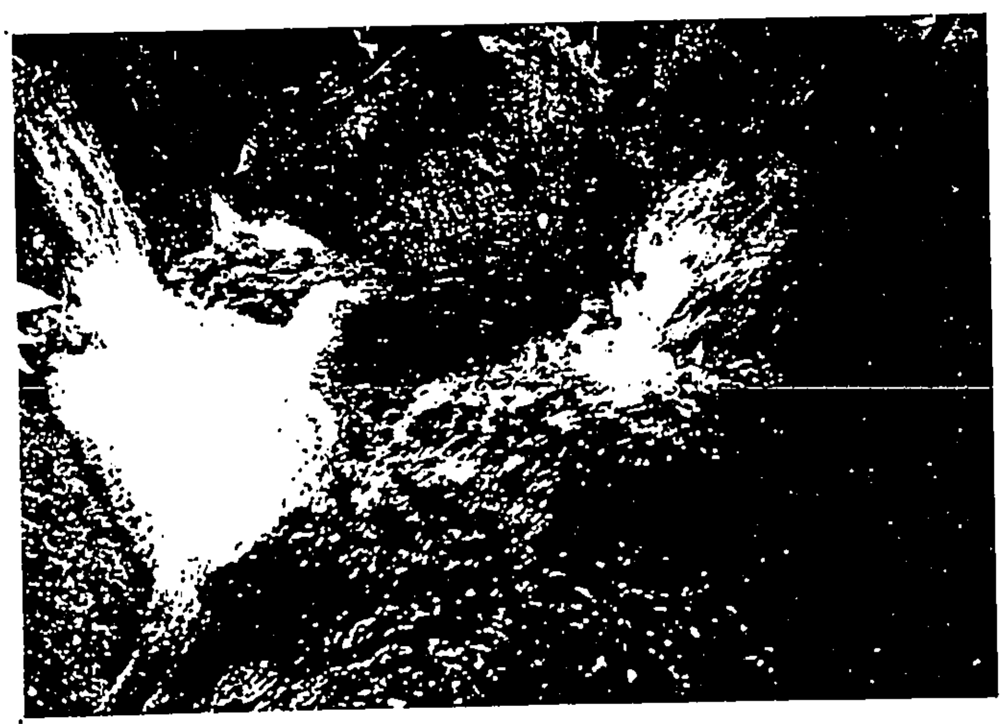
A. Station III or Weir station

B. Diversion weir

C. Makaleha gate to tunnel. Gate is closed.

A. Station II or Spring station



B. Spring surface flow as it joins the mainstream.
On the left is outlet A and the right is outlet B.

A. Waterfall

B. Intermittent no. 1

C. Intermittent no. 2

A. Waterfall as it joins the main-stream just below stn. I.

B. Intermittent no. 1 on the left bank between stn II and stn III.

C. Intermittent no. 2 on the left bank between stn II and stn III just down-stream of no. 1.

Biological Reconnaissance of Makaleha Tributary and the Mainstream Channel for Kapaa Stream, Kauai

by

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Introduction

This study was made for Portugal and Associates in connection with a proposed well for the Kauai County Board of Water Supply in the vicinity of Makaleha Stream, a tributary of Kapaa Stream.

Streams were an essential part in the sustenance and growth of Hawaiian culture. The latest survey showed no less than 336 permanent streams (Timbol and Maciolek 1978). Water from most of these streams has been diverted for agriculture, industrial and domestic uses. The continuing increased demand for water for cultural purposes has placed great pressure to modify and develop the remaining exploitable streams. At the same time, there is an increased environmental awareness among the citizenry. Decisions regarding water use are becoming more and more important.

Streams also provide habitat for a variety of aquatic animals. Freshwater dwelling fishes, shrimps and prawns, and at least one snail are descendants of marine forms. The goby fishes spend their entire adult lives in freshwater yet must spend their larval lives as members of the marine zooplankton community. For example, the _Awaous stamineus_ ('o'opu-nākea) migrates downstream to spawn in either fresh or estuarine water. Female fish attach hundreds of eggs to the surface of rocks where they are fertilized by male fish. Within 24 hours, the eggs hatch and the larvae are swept downstream and into the sea. These larvae then metamorphose into fry known as _hinana_ near the mouths of streams, settle on appropriate substrate, and migrate upstream to their places of permanent residences (Ego 1956). This goby fish, as well as most endemic freshwater macrofauna, must have suitable environmental conditions throughout the stream channel for their upstream and downstream migrations.

The objectives of this study are:
1) to compile a list of resident aquatic macrofauna in Makaleha tributary and the mainstream channel for Kapaa Stream;
2) to identify species of sport, subsistence or commercial fishery value as well as rare, threatened or endangered species present;
3) to determine distribution and relative abundances of aquatic macrofauna for Makaleha tributary and for the mainstream Kapaa;
4) to discuss the possible effects of dewatering on important stream macrofauna; and
5) to make an assessment of the stream's ecological quality status on the basis of its biological and physical features.

As far as can be determined, there are no published biological work on Makaleha tributary or Kapaa Stream.

Study Area

Makaleha tributary, located in Kapaa on eastern Kauai, flows continously year round. Water is exported from its channels by way of the Makaleha Ditch for irrigation of sugarcane. The amount diverted for such purpose has been recorded since 1936. The average, from 1937 through 1975, was 6.73 ft^3/s (0.191 m^3/s) with a maximum of 31 ft^3/s (0.88 m^3/s) to no flow at times (USGS 1976). Another diversion, Kapahi Ditch, exports water from the mainstream channel of Kapaa Stream below the Makaleha Ditch.

Methods and Materials

Physical Parameters

Each sampling site was examined visually, according to bottom type, vegetative cover, water clarity, and flow velocity. Bottom type was determined subjectively. The composition of the substrate was approximated (i. e. bedrock 60%, boulder 40%) using the following modified Wentworth classification of particle size:

Substrate	Size Range (mm) or Description
Bedrock	solid, lava slab
Boulder	250-4000
Cobble	65-250
Gravel	5-65
Sand	1-5
Silt	1
Plant Materials	Mosses, liverwort, filamentous algae, leaf litter in various stages of decomposition

Water clarity as an indication of the amount of suspended sediment present was determined subjectively. The term clear indicates visibility greater than 600 mm depth and slightly turbid corresponded to visibility at between 150 and 600 mm depth.

Flow velocity was measured by timing the movement of a float over a known distance. Repeated trials were made until three results were obtained that appeared representative of the main body of flow. Velocity was reported as an average of these three measurements.

Biological Parameters

A basic area of 20 x 1 m of stream channel was examined for each sampling area. Conspicuous animals (1/2 inch minimum size) which could be seen were identified and counted. When necessary, a face mask and snorkel were used. Boulders, rocks, and stones were examined for snails and insect larvae. Data is reported in a semi-quantitative basis. Absent (0) means that the species was not seen at that site. Uncommon (+) indicates that only one animal was sighted, while common (++) means that between 2 and 5 were observed. Abundant (+++) means between 6 and 10 were seen, and very abundant (++++) means many individuals, from 11 to 100 or more.

Terms used in designating the origin of animals are: endemic, means occuring naturally in Hawaii only; indigenous, means occuring naturally in Hawaii and also elsewhere; native species include both endemic and indigenous; alien, means that the animal was brought to Hawaii either intentionally or accidentally. A species has economic value if it has sport, recreational, subsistence or commercial value. Amphidromous species are those which engage in completely free movement between fresh and marine water, not for the purpose of breeding (Myers 1949). This behavior involves the passive downstream passage of eggs or larvae to the ocean during freshet flow with later active upstream migration.

The list of biota was checked for endangered and threatened species using the following list and scientific publications: USFWS List of Endangered and Threatened Species (1977), Deacon et al. (1979) and Miller (1972). Endangered species means that species is in danger of extinction throughout all or significant portion of its range (Deacon et al. 1979). A threatened species is one which is likely to become threatened or endangered by relatively minor disturbances to their habitat or that require additional information to determine their status (Deacon et al. 1979). These definitions do not have legal status under the Federal Rare and Endangered Species Law.

Streamside vegetation were identified only with their common names. Their scientific names can be obtained by using any of the numerous books on Hawaiian plants.

Results

Field work was done on two successive days, August 7 and 8, 1986.

Sampling Stations

Four sampling stations were studied, two on Makaleha tributary and two on the mainstream channel for Kapaa Stream. Their approximate locations are shown in Figure 1.

Station 1. Upper Makaleha, elevation 1000 ft. Located at the upper reaches of Makaleha, this station is just upstream of the immediate area of the proposed well. The water at the time of sampling was cool (73°F = 22.8°C), clear and fast flowing measured at about 0.4 m/second. The 20 m length of stream sampled was characterized subjectively as 95% cascade and 5% fast flowing pools. The substrate consists mostly of bedrock and large boulders and hardly any gravel; no sand nor silt (98 - 2% ratio). There is no vegetative canopy covering the sampling station. Stream side vegetation is about 80% yellow guava and the rest is *Lantana* and uluhe fern. The dominant vegetation in the drainage area is hau bush. Two areas were sampled for aquatic macrofauna in this sampling station.

Station 2. Lower Makaleha, elevation 600 ft. This is about 0.7 mile downstream of Station 1. It is in the vicinity of the Makaleha Ditch intake. The water was cool (76°F = 24.4°C), clear and fast flowing; about 0.4 m/second on the natural channel, 0.6 m/second on the open ditch leading to the intake but very slow (0.04 m/second) downstream of the diversion weir. The substrate

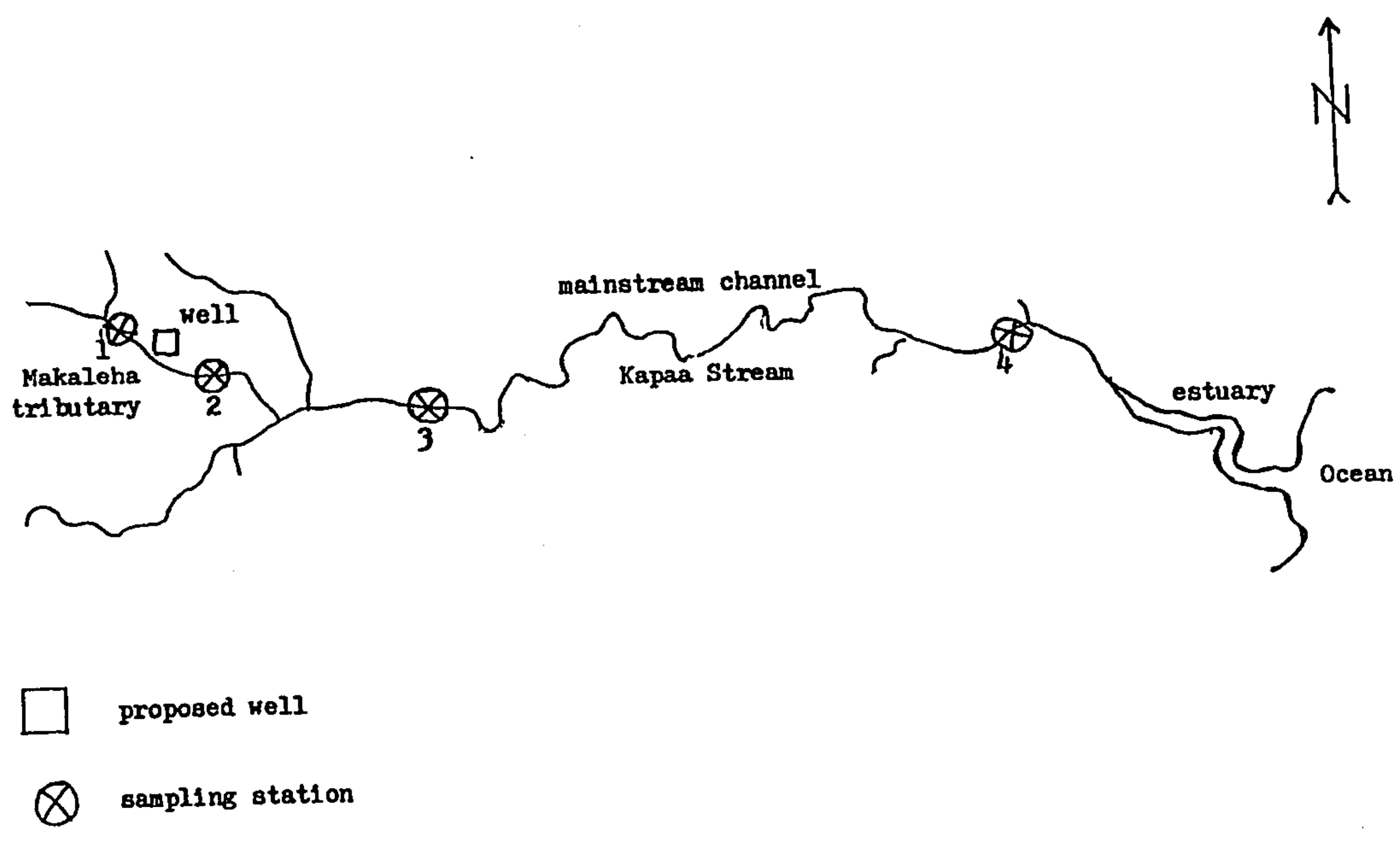

Figure 1. Stream channels for Makaleha tributary and mainstream Kapaa showing locations of sampling stations and proposed well.

on the natural channel consists of 60% gravel, 10% boulder and 30% of sand and silt. The riparian vegetation consists of hau on the right side, rose apple on the left side. This stretch of the stream channel is covered totally by vegetative canopy of hau and rose apple. Three areas were sampled: on the natural channel upstream of the diversion weir, on the natural channel downstream of the diversion weir, and on the open ditch leading to the intake.

Station 3. Kapaa mainstream channel, elevation 400 ft. This is located about 1.1 miles downstream of station 2. It is in the vicinity of the gauging station for the Kapahi Ditch. The physical features for this sampling station were measured at the natural channel leading to the ditch intake. Water was clear, cool (76°F = 24.4°C) and fast flowing (0.6 m/second). The substrate consisted of about 60% gravel, 10% boulder, and 30% sand and silt. The riparian vegetation is hau on both sides and the station has no vegetative canopy. Two areas were sampled: one at the above described location and the second on the pool downstream of the diversion weir. The second area had slightly turbid water, was warmer (80°F = 26.7°C) and was not flowing.

Station 4. Lower Kapaa mainstream, elevation about 50 ft. This is about 4.5 miles downstream of station 3 and about 2 miles upstream of the stream mouth. The water was slightly turbid, slow flowing (0.3 m/second) and warmer (83°F = 28.3°C). The substrate consisted of gravel (50 %) and sand (50%) but the whole area is covered with a thin layer of silt. The riparian vegetation consisted of yellow guava on the right bank and hau on the left bank. The station is covered in about 60% of the overhead area, the cover consisting of monkeypod.

Biological

These biological data are representative only of Makaleha tributary and the mainstream channel for Kapaa Stream (excluding the estuary). Other tributaries for Kapaa Stream (Kapahi, Kealia, Maiakii, Moalepe, and Mimino) were not sampled.

The visual observation technique used here has unique features, different from the electroshocking method used by other workers such as USFWS (1977), Norton et al. (1978), Timbol and Maciolek (1978), and Kinzie and Ford (1982). Visual observation is more "efficient" on non-secretive species (i.e. A. stamineus or 'o'opu-nākea). On the other hand, electroshocking allows the detection and capture of species that are hidden diurnally (i.e. Clarias fuscus or Chinese catfish). The limitations of using electrocking are discussed in Maciolek and Timbol (1980), Riggs (1953), and Larimore (1961). The strengths and weaknesses of each technique should be considered in comparing results of one technique with those of the other.

1. Inventory. At least 18 species of aquatic and semi-aquatic animals were found in Makaleha tributary and mainstream Kapaa (Table 1). There are 9 fishes, 3 amphibians, 4 crustaceans, 1 mollusk, and 1 insect. Eight species are native to Hawaii while 10 are alien. Of the eight natives, 6 are endemic and of the endemics, 4 are fishes.

The important components of the aquatic macrofauna are the amphidromous species, namely 4 fishes, and 2 crustaceans. Of these 6 amphidromous species, 2 (A. stamineus, L. concolor) are listed as threatened in scientific publications (see Table 1). The L. concolor, the rarest of Hawaiian freshwater fishes, had been recommended for the endangered species list (Maciolek 1977) but "presently lacks sufficient data on which such listing may be warranted" (Kinzie et al. 1984, p. 1).

Table 1. List of Aquatic Macrofauna in Makaleha tributary and Kapaa mainstream, Kauai (August 7-8, 1986).

Scientific Name	Local Name	Origin	List[1]
Fishes			
1. *Awaous genivittatus*	'o'opu-naniha	indigenous	none
2. *Awaous stamineus*	'o'opu-nākea	endemic	depleted (Miller 1972), special concern (Deacon *et al.* 1979)
3. *Eleotris sandwicensis*	'o'opu-ōkuhe	endemic	none
4. *Gambusia affinis*	mosquitofish	alien	none
5. *Kuhlia sandvicensis*	aholehole	endemic	none
6. *Lentipes concolor*	'o'opu-alamo'o	endemic	Special concern (Deacon *et al.* 1979)
7. *Poecilia reticulata*	wild guppy	alien	none
8. *Sarotherodon mossambica*	tilapia	alien	none
9. *Xiphophorus helleri*	swordtail	alien	none
Amphibians			
1. *Bufo marinus* (eggs, tadpoles)	toad	alien	none
2. *Rana rugosa* (tadpoles, young)	wrinkled frog	alien	none
3. *Rana catesbeiana* (tadpoles)	bullfrog	alien	none
Crustaceans			
1. *Atya bisulcata*	'ōpae-kala'ole	endemic	none
2. *Macrobrachium grandimanus*	'ōpae-'oeha'a	endemic	none
3. *Macrobrachium lar*	Tahitian prawn	alien	none
4. *Procambarus clarkii*	crayfish	alien	none
Mollusks			
1. *Melania* sp.	pond snail	indigenous	none
Insects			
1. *Cheumatopsyche* sp.	caddisfly	alien	none

[1]Considered as rare, endangered or depleted in official register or scientific publications.

The more important of these resident animals are the two threatened fish species (L. concolor, A. stamineus), the endemic shrimp, A. bisulcata, and the alien fish, S. mossambica. Each is briefly described as follows:

a. Lentipes concolor ('o'opu-alamo'o)
The L. concolor is a small goby (up to 8 cm, from tip to snout to base of caudal fin) that exhibits sexual dimorphism. Its body is subcylindrical, with a few small, scattered cycloid scales on the posterior half of the body. The male is larger with a brownish anterior half of the body and bright orange to purple posteriorly. The female is brownish on its entire body. The life history of the L. concolor has not been fully studied although some information is available in Lau (1973), Maciolek (1977), Jordan and Evermann(1903), Timbol, Sutter and Parrish (1980), Kinzie and Ford (1982), Kinzie et al. (1984), and Nishimoto and Fitzsimons (1986). Mature L. concolor can be found in middle and upper reaches of the stream, from 50 to 500 m elevation. Unlike the A. stamineus (next) which exhibits downstream migrations in association with freshets or flash floods for spawning purposes (1956), the L. concolor probably has no spawning migration but spawns throughout the length of a stream (Nishimoto and Fitzimons 1986).

b. Awaous stamineus ('o'opu-nākea)
This goby fish is the largest (up to 35 cm) of the endemic freshwater gobies. The adults reside in the upper and middle reaches (50 - 300 m elevation) of the stream. It migrates downstream to spawn. The larvae spend some time in the sea and the resulting postlarvae return up the streams. This goby supports a limited, ethnic fishery on Kauai. It was last sold for $9.89/lb at Kapaa Big Save Store in December 1985. Additional information regarding this goby fish is found in the introductory section.

c. Sarotherodon mossambica (tilapia)
This alien, cichlid fish was first brought to Hawaii in 1951 from Singapore. It has variable color from dark brown grey to silver grey, sometimes with about six verticle dark bands. The dorsal fin with 27-29 spiny and soft dorsal rays. It can attain a weight from three to five pounds. While it seems to prefer brackish water found in the mouths of rivers, it can live and reproduce in pure fresh water. It has some economic value, as bait fish for tuna and food fish. Modest quantities are sold in local markets. It provides good fishing especially for youngsters.

d. Atya bisulcata ('ōpae-kala'ole)
This small, endemic caridean decapod shrimp, attains only up to 8 cm length. The adults live in the middle and upper reaches of streams that flow year-round. Postlarval atyids are commonly found in the lower reaches (see Table 2). The A. bisulcata ranges from olive brown to black in color. It is a detrital (suspended organic matter) feeder and usually abundant in most streams where it thrives in fast-flowing riffles. This shrimp is amphidromous but it has been suggested that it can also complete its life cycle in freshwater (Couret 1976). It is harvested for home consumption on Kauai and possibly on the other islands except on Oahu.

2. Distribution and Relative Abundances. Of the 18 species only one, A. stamineus ('o'opu-nākea), was found in all four stations sampled. This species is ubiquitous in most streams in the State (Timbol 1977). Two species (A.

bisulcata, Cheumatopsyche sp.) were found only in Makaleha tributary (Stations 1 and 2) while 8 were found only in the Kapaa mainstream channel. In general, there is an increase in the number of species in a downstream direction.

An important feature is the low density of the two threatened species. The A. stamineus (No. 2 among the fishes in Table 2) is common, meaning there were only between 2 and 5 in a 20 x 1 m stretch of stream channel. The fishes were larger at the upper and middle sampling stations (Stations 1 and 2). Those in Station 3 were of mixed sizes, large and small, while those in the lowest elevation (Station 4) consisted only of postlarvae (hinana). The second threatened species, L. concolor, was not only low in density but was also found only in the upper reaches of Makaleha tributary (Station 1). All the L. concolor gobies were adults, between 8 and 13 cm total length.

Physical Features

Although Makaleha tributary and the mainstream channel for Kapaa Stream form a single continuous channel from the Makaleha Mountain down to the sea, the physical features of the two are different. Makaleha tributary is characterized by fast flowing, clear, cool water. Kapaa mainstream is characterized by slightly turbid, slower flow and warmer water (see Sampling Stations). Water from both streams is diverted for agricultural purposes by way of the Makaleha and Kapahi ditches. Including the aquatic macrofauna and vegetation found in the drainage areas, the upper Makaleha tributary has the characteristics of an almost pristine stream with an Ecological Quality Status I (Pristine-Preservation) according to the classification set by Timbol and Maciolek (1978) and the Hawaii Department of Health (1977). A stream designated as Pristine-Preservation has a high environmental (no cultural modifications) and biological quality (presence of the economically valuable A. stamineus and the rarest of freshwater gobies, L. concolor: both threatened species). On the other hand, the lower Makaleha and mainstream Kapaa suffer from dewatering by way of Makaleha and Kapahi ditches. Roads also follow and crisscross both segments, sources of oil and silt. These have Ecological Quality Status III (Exploitive-Consumptive). An exploitive-consumptive stream has moderate to low natural and/or water quality. It is well exploited, modified and degraded.

Potential Adverse Effect of Dewatering

A simplistic description of a perennial stream's immediate water source is a water table located at a higher level than the stream floor. The yielding portion of the water table shrinks and expands with the dry and wet seasons (Hynes 1975). Artificial withdrawal (dewatering, as in pumping out) from the water table could result in the lowering of flow velocity, decrease in water depth, and some loss of stream habitat. The magnitude of these losses depend upon how much water is withdrawn.

The potential adverse effect of dewatering on the aquatic macrofauna could be numerous. A discussion of all known potential adverse effects will be voluminous and beyond the scope of this study. Discussions will be limited to elevated water temperature, an immediate result of dewatering. Lowered water level in the channel will lead to a rapid increase of water temperature, among other effects.

The effects of elevated water temperatures can be divided into three categories: behavioral, metabolic, and lethal. Behavioral effects include the immediate positive and negative responses. Metabolic effects are "delayed action" effects as in growth acceleration resulting in the inability to reach and/or pass a critical point in the life cycle (Andrewartha and Birch 1954). Lethal temperatures define the range within which the animal will die.

Table 2. Distribution and Relative Abundances of Aquatic Macrofauna in Makaleha tributary and Kapaa mainstream, Kauai (Aug. 7-8, 1986) (++++ = very abundant, +++ = abundant, ++ = common, + = uncommon, 0 = absent or not seen)

Scientific Name	Sampling Stations: Makaleha tributary I	Makaleha tributary II	Mainstream Channel Kapaa III	Mainstream Channel Kapaa IV
Fishes				
1. *Awacus genevittatus*	0	0	0	++
2. *Awacus stamineus*	++	++	+	+++
3. *Eleotris sandwicensis*	0	0	0	+++
4. *Gambusia affinis*	0	+	++	0
5. *Kuhlia sandvicensis*	0	0	++	+
6. *Lentipes concolor*	++	0	0	0
7. *Poecilia reticulata*	0	++	++++	+++
8. *Sarotherodon mossambica*	0	0	0	++
9. *Xiphophorus helleri*	0	+	+++	0
Amphibians				
1. *Bufo marinus*	0	0	0	++
2. *Rana rugosa*	+++	0	++++	0
3. *Rana catesbeiana*	+++	+++	0	+
Crustaceans				
1. *Atya bisulcata*	+++	+++	0	0
2. *Macrobrachium grandimanus*	0	0	0	++
3. *Macrobrachium lar*	0	0	0	++
4. *Procambarus clarkii*	0	0	++	0
Mollusks				
1. *Melania* sp.	0	0	+++	0
Insects				
1. *Cheumatopsyche* sp.	+++	++	0	0

1. Behavioral. A motile animal (i.e. fish) will elect to leave an area when physicochemical conditions become unfavorable, and will generally not voluntarily remain in the area until conditions become lethal. In a study on channelized streams, highest temperatures cross-stream were measured near the edge of the channel where water velocity is lowest (Parrish et al. 1978). It is easiest for stream animals to move at the channel edge. This effect would make it difficult for the postlarvae to complete a normal migration upstream from the sea.

2. Metabolic. Laboratory growth tests showed increased growth rate with increasing temperature up to 30-32°C in the postlarvae *A. stamineus* (Parrish et al. 1978, Hathaway 1978). Above these temperatures, growth rate was reduced. At the least, this growth characteristic constitutes a chronic physiological stress.

3. Lethal. The upper lethal temperature limits for *A. stamineus* ('o'opu-nākea) adults in laboratory tests ranged between 37.2 and 38.8°C with 50% of the animals dead (LT_{50}) at 38.1°C (Hathaway 1978). Postlarvae (hinana) were more resistent with a range between 39.0 and 39.3°C and LT_{50} at 39.3°C. *L. concolor* ('o'opu-alamo'o) adults died at between 35.9 and 36.3°C with the LT_{50} at 36.1°C. The endemic shrimp, *A. bisulcata* ('ōpae-kala'ole) adults died at between 34.0 and 34.5°C with LT_{50} at 34.2°C. On the other hand, Hathaway (1978) found the alien species, *S. mossambica* (tilapia), to be much more tolerant of elevated temperatures. It had lethal temperatures of between 42.7 and 43.1°C with LT_{50} of 42.9°C. Thus, the tilapia will survive the three endemic animals.

Conclusions and Recommendations

Conclusions

1. The upper Makaleha tributary is of high quality. In contrast, the lower Makaleha tributary and the mainstream channel for Kapaa Stream are of poor quality and highly degraded.

2. The extent of dewatering will determine the extent of elevated temperatures in the remaining water. When the water becomes too warm, the stream animals will leave the area if they can. If they are unable to leave, the animals will undergo variable growth rate. If the water becomes excessively heated, the endemic species will die first.

Recommendation

The adverse impact of dewatering on vertebrate and invertebrate animal populations can be minimized by controlling the removal of water to provide adequate flows during the dry seasons. Specifically, enough water should be left in the channel to maintain water temperature at no more than 30°C. The lethal temperatures discussed in the result section are laboratory values. In the actual field situation, mortality would normally occur at somewhat lower temperatures and successful spawning would be restricted to much lower temperatures yet.

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APPENDIX D

FLORA SURVEY

Char & Associates

FLORA SURVEY

MAKALEHA STREAM, ISLAND OF KAUA'I

by

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SUMMARY

A botanical survey was made along Kapa'a road from the water tank to Makaleha Stream, and thence along the stream to the site of the springs and the proposed catchment. A total of 123 plant species (26 ferns and fern allies, 97 flowering plants) were found in three basic habitats: open field, stream bank, and closed forest. By far, most species were exotic, having been introduced after the arrival of Western man, though a number of native and a few of Polynesian introduction were also encountered. No species listed, proposed, or candidate for listing by Federal or State government as rare, threatened, or endangered were found in the study area. A list of all species found in the course of this study is given at the end of this report.

METHODS

A walk-through survey method was employed for this work. Notes were made on community composition and structure. Plants not recognized in the field were collected and brought back for identification. The work was carried out on 22 December 1986 by two professional botanists, and required 16 person-hours of field time.

DESCRIPTION OF PLANT COMMUNITIES

OPEN FIELD

This type of habitat was restricted to the area immediately bordering the water tank and road. The dominant was California grass (*Brachiaria mutica*), a valuable forage grass of adjacent pastures. Along fences, and elsewhere, where weed clearing is not carried out, tree species from the nearby forests were found to be invading: guava (*Psidium guajava*), haole koa (*Leucaena leucocephala*), roseapple (*Syzygium jambos*), and swamp gum (*Eucalyptus robusta*). Around the water tank and along the road, constant disturbance of the soil favored the growth of many species of annual herbaceous weeds and forbs. Two plantings were also showing signs of spreading: coconut (*Cocos nucifera*) and wedelia (*Wedelia trilobata*). In this habitat, all species were exotic; no natives or Polynesian introductions were found.

STREAM BANK

This was the most restricted of the habitat types, most extensive along the lower part of the stream where the banks were low, and the forest set back a bit. It was highly disturbed by trampling, cutting, and flooding. Steeper areas were dominated by palm grass (*Setaria palmaefolia*) and yellow ginger (*Hedychium flavescens*). Level areas subject to trampling were dominated by annual and perennial weeds of low stature, generally less than a foot high. Kamanamana (Adenostemma lavenia) was a common native plant in such situations. Areas not subject to trampling were dominated by weeds of slightly higher stature, but still less than two feet high, including a number of exotic ferns. The grass honohono-kukui (Oplismenus hirtellus) was abundant throughout, and might well be considered the dominant plant, though many other species were present in almost equal quantities. The only plants of greater stature were banana, or mai'a, (Musa x paradisiaca), guava (Psidium guajava), and the highly invasive and undesirable rose myrtle (Rhodomyrtus tomentosus).

CLOSED FOREST

This habitat type covered the largest area within the study site, and was represented by a number of localized variations. Trees were generally less than 25 feet tall, with only occasional trees emerging above the canopy. The emergents were Albizia sp., formerly a common forestry planting, now considered undesirable because of the weakness of the wood. The closed canopy consisted of hau (Hibiscus tiliaceus), roseapple (Syzygium jambos), and kukui (Aleurites moluccana). Locally, any one or more of these could be found coexisting with each other or alone, even excluding all other species. In the upper reaches of the study area, especially near the springs, mountainapple (Syzygium malaccensis) tended to replace roseapple (Syzygium jambos). On the left bank of the stream (looking upstream) there were two extensive patches of bamboo. Less commonly, scattered elements of the native forest,such as 'ohia-lehua (Metrosideros species), tree ferns (Cibotium species), and kopiko (Psychotria aff. kaduana) were found.

POTENTIAL ENVIRONMENTAL PROBLEMS AND CONCERNS

There are no plant communities or individual species located in the study site in need of protection. No rare, endangered, or threatened species, as listed by the U.S. Fish and Wildlife service (1980) were found. The best examples of native forest were found beneath cliffs on the left side of the stream (looking upstream), well out of the area proposed for the pipeline. A number of ferns and the single species of lobeliad are of some botanical interest, though apparently not rare.

The right side (looking upstream) was an almost unbroken tangle of Syzygium (rose- and mountainapple) and hau (Hibiscus) over boulders. In at least one area just below the confluence of the springs and the stream, there is a ridge that very closely approaches the streamside. This occurs in two places on the left bank of the stream. While no floristic problems are foreseen, the density of the tangle over such a narrow, bouldery area may present engineering problems in construction of an access roadway. There may be further problems with road construction and stream quality (erosion and siltation).

PLANT SPECIES FOUND IN THE STUDY SITE

A list of all species found in the course of this survey follows. Plants are arranged in three groups: Ferns and Fern Allies, Monocots, and Dicots. Within each group, plants are arranged alphabetically by family, and in alphabetic order within each family. Names of ferns and fern allies follow the system of Lamoureux (unpublished manuscript, in ed.) Names of flowering plants follow the system of St. John (1973) except where names in more recent treatments have been accepted. Common vernacular names follow the scientific names, and generally conform to Porter's (1972) and St. John's usage. The status of the species is then given using the following code: endemic (E) - species native only to Hawai'i; indigenous (I) - species native to Hawai'i as well as other places; Polynesian introductions (P) - species not native to Hawai'i but brought by the Hawaiians; and exotic (X) - species not native to Hawai'i but brought subsequent to the arrival of Western man. Finally, note is made of the presence (+) or absence (-) of the species in each of the three habitats: O - open field; S - stream bank; F - closed forest.

PLANT SPECIES LIST

FERNS AND FERN ALLIES

		status	habitat O	S	F
Adiantaceae					
Adiantum capillus-veneris L.	'iwa'iwa	I	-	-	+
Athyriaceae					
Athyrium macraei (Hook. & Grev.) Copel.	athyrium	E	-	-	+
Athyriopsis japonica (Thunb.) Ching	athyriopsis	X	-	-	+
Diplazium sandwichianum (Presl.) Diels	ho'i'o	X	-	-	+
Blechnaceae					
Blechnum occidentale L.	blechnum	X	-	+	+
Dicksoniaceae					
Cibotium chamissoi Kaulf.	hapu'u-i'i	E	-	-	+
Cibotium splendens (Gaud.) Krajina ex Skottsb.	hapu'u-pulu	E	-	-	+
Elaphoglossaceae					
Elaphoglossum crassifolium (Gaud.) Anders. & Crosby	'ekaha-ula	E	-	-	+
Gleicheniaceae					
Dicranopteris linearis (Burm.) Underw.	uluhe	I	-	-	+
Grammitaceae					
Grammitis tenella Kaulf.	kolokolo	E	-	-	+
Hymenophyllaceae					
Gonocormus minutus (Blume) v.d.Bosch	gonocormus	I	-	-	+
Lindsaeaceae					
Sphenomeris chinensis (L.) Maxon	pala'a	I	-	-	+
Lycopodiaceae					
Lycopodium phyllanthum Hook. & Arn.	wawae'iole	E	-	-	+
Nephrolepidaceae					
Nephrolepis biserrata (Sw.) Schott	fishtail fern	X	+	+	-
Nephrolepis exaltata (L.) Schott	ni'ani'au	I	-	-	+
Nephrolepis multiflora (Roxb.) Jarrett ex Morton	hairy sword-fern	X	+	+	+
Polypodiaceae					
Phlebodium aureum (L.) J. Sm	laua'e-haole	X	-	-	+
Phymatosorus scolopendria (Burm.) Picchi-Serm.	laua'e	X	-	+	+
Pleopeltis thunbergiana Kaulf.	'ekaha-'akolea	I	-	-	+
Psilotaceae					
Psilotum nudum (L.) Beauv.	moa, pipi	I	-	+	+

Selaginellaceae			
Selaginella arbuscula (Kaulf.) Spring	lepelepe-a-moa	E	- - +
Thelypteridaceae			
Christella dentata (Forsk.) Brownsey & Jermy	downy wood-fern	X	+ + +
Christella parasitica (L.) Leveille	oak-fern	X	+ + +
Cyclosorus interruptus (Willd.) H. Ito	cyclosorus	I	- - +
Pneumatopteris sandwicensis (Brack.) Holtt.	pneumatopteris	E	- - +
Vittariaceae			
Vittaria elongata Sw.	oheohe	I	- - +

FLOWERING PLANTS

MONOCOTS

Araceae			
Alocasia macrorrhiza (L.) Schott	'ape	P	+ + -
Colocasia esculenta (L.) Schott	taro	P	- + +
Commelinaceae			
Commelina diffusa Burm. f.	honohono	X	+ + +
Cyperaceae			
Cyperus aff. cyperoides (L.) Ktze.	cyperus	I	- + +
Kyllinga brevifolia Rottb.	kyllinga	X	- + +
Dioscoreaceae			
Dioscorea bulbifera L.	pi'oi	P	- - +
Dioscorea pentaphylla L.	pi'ia	P	- + +
Gramineae			
Bamboo sp. 1		X	+ - -
Bamboo sp. 2		X?	- - +
Brachiaria mutica (Forsk.) Stapf	California grass	X	+ - -
Cenchrus echinatus L.	sandbur	X	+ - -
Chloris inflata Link	swollen finger-grass	X	+ - -
Coix lachryma-jobi L.	Job's tears	X	+ + -
Cynodon dactylon (L.) Pers.	Bermuda grass	X	+ - -
Digitaria sp.	crab grass	X	- + -
Eleusine indica (L.) Gaertn.	goose grass	X	+ - -
Oplismenus hirtellus (L.) Beauv.	honohono-kukui	X	- + +
Paspalum conjugatum Berg.	Hilo grass	X	+ + -
Paspalum fimbriatum HBK	Columbia grass	X	+ - -
Paspalum sp.		X	+ - -
Sacciolepis indica (L.) Chase	Glenwood grass	X	+ + +
Setaria geniculata (Poir.) Beauv.	perennial foxtail	X	- - +
Setaria palmaefolia (Koen.) Stapf	palm grass	X	- + -
Sporobolus aff. africanus (Poir.) Robyns and Tournay	African dropseed	X	+ + -

Iridaceae			
Tritonia crocosmifolia Nichols.	montbretia	X	- + -
Liliaceae			
Cordyline terminalis (L.) Kunth	ti	P	- + +
Musaceae			
Musa x *paradisiaca* L.	mai'a	P	- + +
Orchidaceae			
Spathoglottis plicata Bl.	spathoglottis	X	+ + +
Palmae			
Cocos nucifera L.	coconut, niu	P	+ - -
Roystonea sp.	royal palm	X	- - +
Pandanaceae			
Freycinetia arborea Gaud.	ie'ie	E	- - +
Pandanus tectorius Warb.	hala	I	- - +
Zingiberaceae			
Hedychium flavescens Carey in Roscoe	yellow ginger	X	+ + -
Zingiber zerumbet (L.) Roscoe in Sm.	'awapuhi kua hiwi	P	- + +

DICOTS

Acanthaceae			
Thunbergia fragrans Roxb.	white thunbergia	X	+ - -
Anacardiaceae			
Mangifera indica L.	mango	X	+ + +
Schinus terebinthifolius Raddi	Christmasberry	X	+ + +
Bignoniaceae			
Spathodea campanulata Beauv.	African tuliptree	X	+ - -
Caryophyllaceae			
Drymaria cordata (L.) Willd. ex R. & S.	drymaria	X	- + +
Compositae			
Adenostemma lavenia (L.) Ktze.	kamanamana	I	- + -
Ageratum conyzoides L.	ageratum	X	+ + -
Bidens pilosa L.	Spanish needle	X	+ + -
Conyza canadensis (L.) Cronq.	Canada fleabane	X	+ + -
Crassocephalum crepidiodes (Benth.) A. Moore	crassocephalum	X	+ + -
Elephantopus mollis HBK.	elephant's foot	X	+ - -
Emilia fosbergii Nicolson	Flora's paintbrush	X	+ + -
Erechtites valerianaefolia (Wolf) DC.	erechtites	X	+ + +
Pluchea odorata (L.) Cass.	pluchea	X	+ + +
Pseudoelephantopus spicatus (Juss. ex Aubl.) Gleason	false elephant's foot	X	- + -

Siegesbeckia orientalis L.	siegesbeckia	X	-	+	-
Vernonia cinerea (L.) Less.	ironweed	X	+	+	-
Youngia japonica (L.) DC.	oriental hawks-beard	X	+	+	+
Wedelia trilobata (L.) Hitchc.	wedelia	X	+	-	-
Unknown composite		X	-	+	-
Convolvulaceae					
Ipomoea alba L.	koali-pehu	I	-	-	+
Ipomoea obscura (L.) Ker-Gawl	bindweed	X	+	-	-
Euphorbiaceae					
Aleurites moluccana J. R. and G. Forst.	kukui	P	-	+	+
Euphorbia geniculata Ortega	wild spurge	X	+	-	-
Euphorbia glomerifera (Millsp.) L. C. Wheeler	spurge	X	+	-	-
Euphorbia hirta L.	hairy spurge	X	+	-	-
Euphorbia thymifolia L.	thyme-leaved spurge	X	+	-	-
Phyllanthus debilis Klein ex Willd.	phyllanthus	X	+	+	-
Lauraceae					
Persea americana Mill	avocado	X	-	+	+
Leguminosae					
Albizia sp.	albizia	X	-	+	+
Cassia lechenaultiana DC.	partridge pea, lauki	X	+	+	-
Desmodium canum (Gmel.) Schinz and Thell.	Spanish-clover	X	+	+	-
Desmodium triflorum (L.) DC.	beggarweed	X	+	-	-
Desmodium uncinatum (Jacq.) DC.	Spanish-clover	X	-	+	-
Indigofera suffruticosa Mill.	indigo	X	+	-	-
Leucaena leucocephala (Lam.) deWit	haole koa	X	+	+	+
Mimosa pudica L.	sleepinggrass, pua-hilahila	X	+	+	-
Phaseolus lathyroides L.	wild bushbean	X	+	-	-
Lobeliaceae					
Cyanea sp.	cyanea	E	-	-	+
Lythraceae					
Cuphea carthagenensis (Jacq.) Macbride	Columbian cuphea	X	+	+	-
Malvaceae					
Hibiscus tiliaceus L.	hau	I	+	+	+
Sida acuta Burm. f.	'ilima	X	+	-	-
Unknown malvacea		X	+	-	-
Myrtaceae					
Eucalyptus robusta Sm.	swamp gum	X	+	-	-
Metrosiderus collina (J.R. and G. Forst.) Gray, subsp. *polymorpha* (Gaud.) Rock	'ohi'a-lehua	E	-	-	+
Metrosideros sp.	'ohi'a-lehua	E	-	-	+
Psidium cattleianum Sabine	strawberry guava	X	-	+	-

Psidium guajava L.	guava	X	+ + +
Rhodomyrtus tomentosa (Ait.) Hassk.	rose myrtle	X	+ + +
Syzygium jambos L.	roseapple	X	+ + +
Syzygium malaccensis L.	mountain apple	P	– – +
Nyctaginaceae			
Pisonia umbellifera (J.R. & G. Forst.) Seem.	papala-kepau	I	– + +
Onagraceae			
Ludwigia octivalvis (Jacq.) Raven	primrose willow	X	– + +
Oxalidaceae			
Oxalis corniculata L.	yellow wood-sorrel	X	+ + –
Piperaceae			
Peperomia tetraphylla (Forst. f.) H. and A.	'ala'ala-wai-nui	E	– – +
Peperomia sp.	'ala'ala-wai-nui	E	– – +
Plantaginaceae			
Plantago major L.	common plantain	X	+ + –
Rosaceae			
Rubus rosaefolius Sm.	thimbleberry	X	– + +
Rubiaceae			
Psychotria aff. *kaduana* (C. & S.) Fosb.	kopiko	E	– – +
Spermacoce laevis Lam.	buttonweed	X	+ – –
Solanaceae			
Cestrum nocturnum L.	night cestrum	X	– + +
Urticaceae			
Boehmeria grandis (H. & A.) Heller	akoka	E	– – +
Pipturus aff. *helleri* Skottsb.	mamaki	E	– – +
Verbenaceae			
Lantana camara L.	lantana, lakana	X	+ + +
Stachytarpheta jamaicensis (L.) Vahl	Jamaica vervain	X	+ + –

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APPENDIX E

WILDLIFE RESOURCES SURVEYS

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FAUNAL SURVEY OF MAKALEHA VALLEY,

KAPAA, KAUAI

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FAUNAL SURVEY OF MAKALEHA VALLEY,
KAPAA, KAUAI

INTRODUCTION

The purpose of this report is to summarize the findings of a one day (23 December 1986) faunal survey of Makaleha Valley, Kapaa, Kauai (for exact locality of survey see Fig. 1). References to pertinent literature as well as unpublished reports and personal communications from ornithologists familiar with the area are provided in order to give a broader perspective of faunal activity in the area and similar habitat elsewhere on Kauai. Finally the possible effects on the faunal community during and following development is discussed.

The objectives of the field survey were:

1- To document which birds occur on the project site and at what relative densities.

2- To determine if endangered species occur on the property and whether or not they might be adversely effected by the proposed development.

2- To compare the results of the field survey with published and unpublished data in order to more accurately describe what species likely occur in the area.

GENERAL SITE DESCRIPTION

Weather during the survey was clear with little or no wind. Habitat along the Makaleha stream is comprised primarily of exotic vegetation while the steep forested walls of the valley contain a greater number of native trees such as Ohia (*Metrosideros collina*). The cleared pasturelands around the water tank area at the mouth of the valley provide an additional habitat type.

STUDY METHODS

Field observations were taken with the aid of binoculars and by listening for vocalizations as I walked along a trail that followed the stream. A series of four minute counts were taken approximately every 100-200 m along the trail (Fig.1). These counts recorded all the birds seen and heard during the four minute time period. These data together with observations made while walking were used to calculate the relative abundance estimates given in Table 1.

Observations of feral mammals were limited to visual evidence in the form of tracks and scats. No attempts were made to trap mammals in order to obtain data on their relative abundance or distribution.

Scientific names used in this report follow those given in the recent (6th edition) American Ornithologists' Union Checklist (A.O.U. 1983) and Hawaii's Birds (Hawaii Audubon Society 1984).

RESULTS AND DISCUSSION

Resident (Native) Birds:

White-tailed Tropicbird (*Phaethon lepturus*)
This seabird occurs on most high volcanic islands in the tropical Pacific (Hawaii Audubon Society 1984); Pratt et al. in press). A total of six White-tailed Tropicbirds were recorded during the survey. All were seen soaring along cliff faces above Makaleha Stream. This species is common on Kauai. They forage at sea but breed and roost on rocky ledges in high mountainous areas.

Common 'Amakihi (*Hemignathus virens*)
One 'Amakihi was seen foraging in a Ohia tree located about 50 m above Makaleha Stream. This

endemic forest bird is widespread and relatively common in the upper elevation forests of all the main Hawaiian islands (Hawaii Audubon Society 1984; Pratt et all. in press). It was a little surprising to find this species in the project area given the low elevation of this site. Typically 'Amakihi are restricted to elevations usually above 2,000 ft. Recent observations on Oahu (S.Conant pers. comm.) and Maui (H.D.Pratt pers. comm.) report 'Amakihi from elevations as low as 800 ft. These birds are likely individuals which may on occasion forage at lower than normal elevation but retreat to higher elevation at night to avoid exposure to mosquito transmitted diseases (H.D. Pratt pers. comm.).

Hawaiian Duck (Koloa) (*Anas wyvilliana*) The endemic and endangered Hawaiian Duck, also known as Koloa, inhabits ponds and streams on Kauai (Shallenberger 1977). It has been reintroduced recently to other islands in Hawaii and appears to be making some strides in recovering from its endangered status (Div. of Forestry and Wildlife unpublished documents, U.S. Fish and Wildlife Service 1985). One Koloa was discovered in Makaleha Stream (see Fig. 1 for locality). This sighting is not unexpected as Koloa typically frequent this type of habitat on Kauai (Berger 1972). Future more long term surveys of Makaleha Stream might reveal whether or not a breeding population occurs in the area or if this sighting merely represents a straggler which may or may not be permanently resident at this site.

Other native birds not recorded on the field survey but which could potentially occur in the Makaleha Valley project area include: 'Apapane (Himatione sanguinea) 'Elepaio (Chasiempis sandwichensis), Black-crowned Night Heron (Nycticorax nycticorax), Wandering Tattler (Heteroscelus incanus) Lesser Golden Plover (Pluvialis dominica fulva) and Short-eared Owl (Asio flammeus sandwichensis) (Berger 1972; Hawaii Audubon Society 1984).

Introduced (Exotic) Birds:

A total of six species of exotic birds were recorded during the field survey (see Table 1). Japanese White-eye (Zosterops japonicus) was the most common. Exotic species which could potentially occur in the area but were not found during the field survey include: White-rumped Shama (Copsychus malabaricus); Red-billed Leiothrix (Leiothrix lutea); Greater Necklaced Laughing-Thrush (Gasrutax caerulatus); House Finch (Carpodacus mexicanus) and Nutmeg Mannikin

(Lonchura punctulata) (Hawaii Audubon Society 1984).

Feral Mammals:

Evidence in the form of both tracks and scats revealed that pigs inhabit the valley. Dog tracks were also seen but these may represent domestic animals rather than feral dogs. The gnawed remains of guava fruits (Psidium guajava) along the trail indicated that mice and rats occur in the area. No trapping was attempted in order to determine their relative abundance. The endangered and endemic Hawaiian Hoary Bat (Lasiurus cinereus) was not recorded on the survey. The abundance and distribution of this species in Hawaii is poorly known. However, Tomich (1986) and van Riper and van Riper III (1982) report L. Cinereus from Kauai in habitat similar to Makaleha Valley. It is therefore possible that bats could occur at this site.

CONCLUSIONS AND RECOMMENDATIONS

Makaleha Valley was found to contain the usual mix of exotic and native birds typical of similar habitat at this elevation elsewhere on Kauai. Some species that were expected were not recorded.

This was undoubtedly due to the limited time devoted to the actual field survey. The presence on native birds in the area suggests that the habitat is suitable for more than just exotic birds.

The construction of a pipeline from Makaleha Spring to the water tank at the mouth of the valley will not likely provide a major negative impact on the forest birds in the valley unless significant sections of the forest are destroyed in the process of the pipe's installation. Of greater concern is the disruption of the stream habitat due to construction. The endangered Hawaiian Duck occurs along the stream and would likely be displaced if the stream were significantly altered during or following the pipe's installation. Should the construction of a road be necessary in order to install the pipeline this alteration of the habitat could have a negative impact in two ways. First, the road construction process could disrupt the ecology of the stream through siltation and thus reduce its usefulness as Koloa habitat. Second, the road could allow greater human intrusion into the area and likewise degrade the habitat for Koloa.

Recommendations:

1- Minimize the disturbance of the habitat during installation of the pipeline.

2- If a road is necessary in order to install the pipeline place it as far back from the stream as possible and allow the vegetation to grow back in and obscure the road following construction of the pipeline.

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29 December 1986

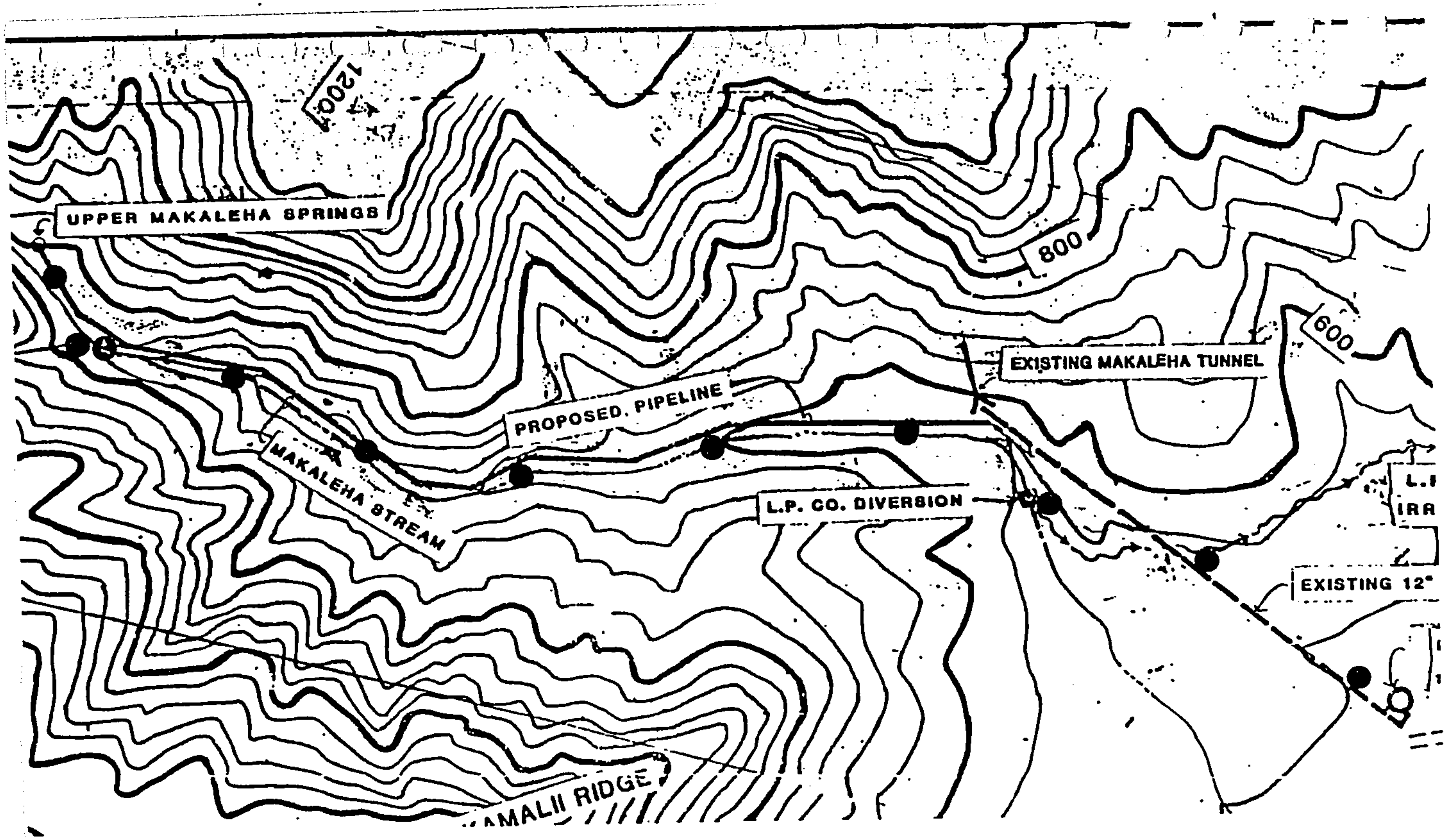

Fig. 1. Project Site Makaleha Valley, Kapaa, Kauai. ✪ = location where Koloa was observed. ● = site of four minute count stations.

TABLE 1

Relative abundance of exotic birds in section of proposed development in Makaleha Valley, Kapaa, Kauai.

COMMON NAME	SCIENTIFIC NAME	RELATIVE ABUNDANCE*
Zebra Dove	*Geopelia striata*	U = 4
Western Meadowlark	*Sturnella neglecta*	U = 2
Northern Cardinal	*Cardinalis cardinalis*	U = 3
Melodious Laughing-thrush	*Garrulax canorus*	C = 6
Common Myna	*Acridotheres tristis*	C = 7
Japanese White-eye	*Zosterops japonicus*	A = 15

* Relative Abundance = Number of times observed during walking survey and/or frequency on four minute counts.

A = Abundant (Average 10+)

C = Common (Average 5-10)

U = Uncommon (Average less than 5)

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A RECONNAISSANCE STUDY

FOR

THE KOLOA OR HAWAIIAN DUCK (*Anas wyvilliana*)

IN THE UPPER MAKALEHA SPRINGS AREA

KAPAA, KAUAI, HAWAII

by

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MAKALEHA SPRINGS

WATER RESOURCE DEVELOPMENT PROJECT

KAPAA,KAUAI

APRIL 1990

A RECONNAISSANCE STUDY FOR THE KOLOA OR HAWAIIAN DUCK (Anas wyvilliana) IN THE UPPER MAKALEHA SPRINGS AREA, KAPAA, KAUAI

Michael H. Kido - April 1990

BACKGROUND

The Koloa, or Hawaiian Duck (Anas wyvilliana), once common on all of the main Hawaiian Islands except Lanai and Kahoolawe (Munro 1944) was once abundant enough to be hunted for food and sport (Swedberg 1967). Due to predation and loss of habitat its numbers have declined significantly and is now listed as endangered by the US Fish and Wildlife Service (Federal Register, Fish and Wildlife Service 1987; 50 CFR 17.11 & 17.12).

In searching the literature and through discussions with wildlife biologists on Kauai, it appears that very little is known about the current range and abundance of the bird, its reproductive biology, or its behavior in the wild. The most comprehensive published report available is that of Swedberg (1967) and subsequently much of the methodology developed for this project is based on Swedberg's observations.

According to Swedberg, the Koloa is highly sensitive to human disturbance and as a consequence prefers habitat not frequented by people. The birds "may use a number of sites on the same day", returning at irregular intervals of a day or more, sometimes abandoning the site altogether when it becomes unsuitable. Swedberg suggests that the Koloa's breeding season is year-round perhaps being more likely to occur from December through May. Nesting apparently has no geographical requirement since Swedberg found "nests or broods...in areas from sea-level to 3,500 foot elevation, from 35 to 125 inches of annual rainfall and in all vegetative types". Nests uncovered by Swedberg were generally near water and associated with hohohono grass (Commelina diffusa). In the photograph of a nest which accompanied the report, I would suggest that Swedberg misidentified this grass which I believe is basket grass (Oplismenus hirtellus) a very common understory groundcover on streambanks in Hawaii.

It is not known whether any one population of Koloa moves from watershed to watershed around the island. In the Hanalei Valley, Koloa are regular inhabitants in the taro patches perhaps increasing in numbers when heavy rains in the mountains drive upland populations down to safer habitat. They are strong, silent flyers almost always observed singly (except during breeding), flying at very low elevation (approximately 12-15 feet above the river by my experience). In Wainiha Valley, I have observed individuals in the river system from sea-level to approximately 600 foot elevation.

STUDY OBJECTIVES

This study addresses the question of whether or not an established breeding population of Koloa exists in the area affected by the Makaleha Springs Water Resource Development Project, Kapaa, Kauai, Hawaii. A sighting of a solitary Koloa by Phillip Bruner in the faunal survey for the project (figure 1) in a section of stream approximately 75-100 meters downstream of the springs site raised the possibility that this individual was a permanent resident of the site and may possibly represent a breeding population in the area. As another consideration raised by the consultant was that the project could adversely affect Koloa habitat, factors which relate to this concern are included in the results and discussion. The effect of the project specifically on available habitat for the Koloa however, is an engineering and hydrological problem which is out of the scope of this study.

METHODS

Given what is known about the biology of the Koloa, the approximate 4000 foot (1220 meter) length of the Makaleha Stream channel was surveyed for suitable Koloa habitat. The Stream channel was walked from the intake and weir (525 ft elevation) to the terminal pools (1000 foot elevation). Both terminal branches of the stream were surveyed (figure 1). Stream sections which appeared to be good Koloa habitat were flagged on the trail to expedite access to them. Where the trail ended (at the Makaleha Springs - 690 foot elevation) the stream channel itself was followed.

A randomly determined schedule of field trips were made, each beginning at different times and varying in length to increase the likelihood of sighting Koloa. On these field trips, the trail was used to access the marked sites and the stream channel was then followed to search for Koloa. Searches were made both while ascending the stream as well as while descending. Special attention was given to the section of stream where the previous Koloa sighting was made. Unless high water made it hazardous, each field survey was conducted to the terminal pool.

Since it is possible that resident Koloa in the Makaleha Mountains may use the Kapaa River waterway to periodically access the marsh areas near the ocean, observations were made from Kealia Bridge over the study period both during morning and evening hours when human disturbance is minimal. Sightings of Koloa in this area may

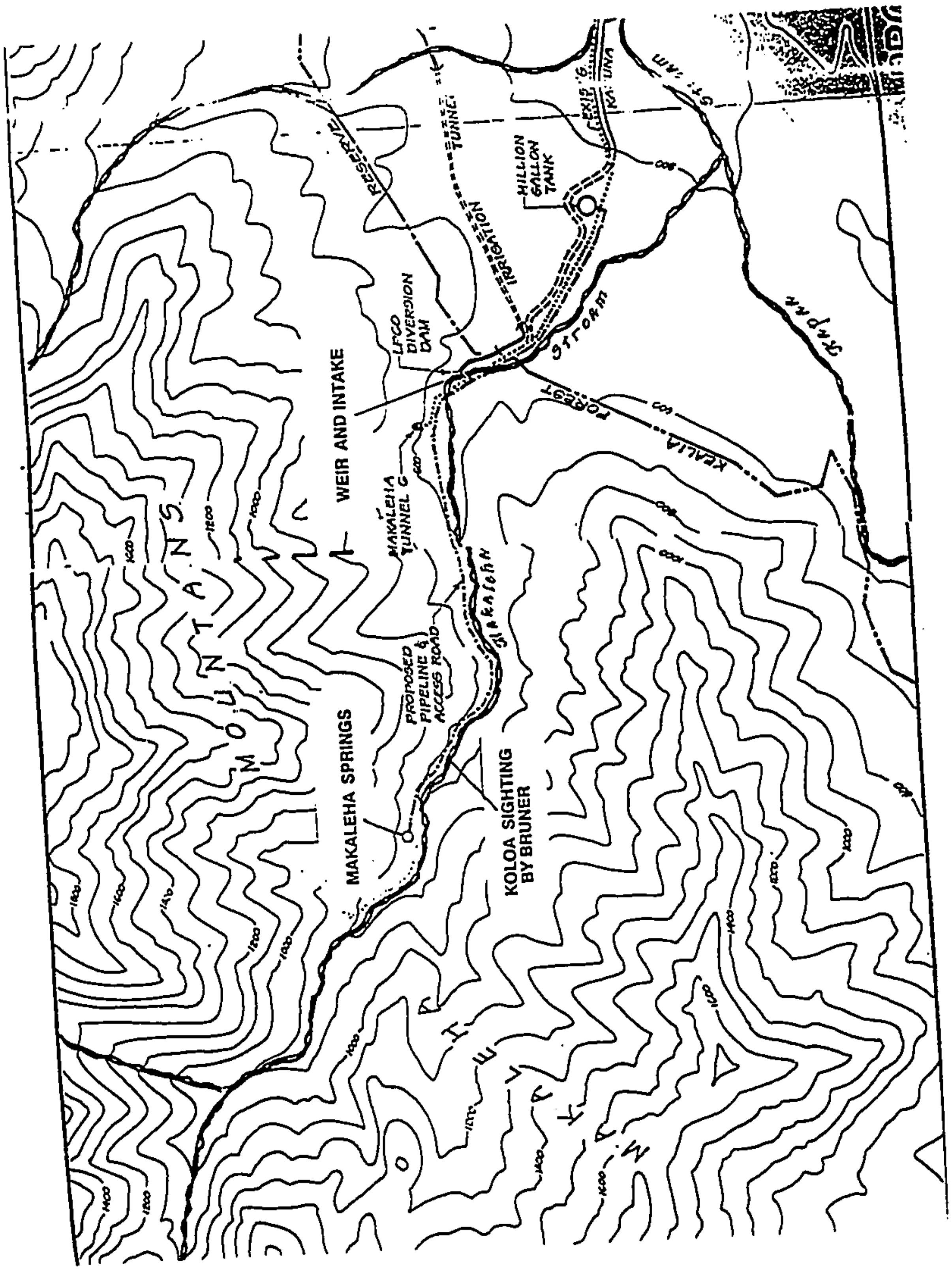

FIGURE 1 - Makaleha Stream , Kapaa, Kauai - Approximate Locations of Koloa Sighting (Bruner) and Observational Sites

be evidence for a permanent population in the mountains.

Altitude readings throughout the project were made with a Gischard Altimeter. The altimeter was zeroed at sea-level and readings are therefore relative to this setting.

RESULTS AND DISCUSSION

Table one summarizes the observational periods for the project. A total of six field trips to Makaleha Stream

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TABLE 1 - Observational Periods for Koloa Duck Reconnaissance Makaleha Stream - Kealia Estuary from 3/16/90 - 4/4/90

Date	am 6	7	8	9	10	11	12	1	2	3	4	5	6	7 pm
3/16							xxxxxxxxxxxxxxxxxx							
3/19			xxxxxxxxxxxx											
3/20													zzzz	
3/21				xxxxxxxxxxx										
3/22													zzzz	
3/23		zzzz												
3/29										xxxxxxxxxx				
4/01	xxxxxxxxxzzz													
4/03													zzzz	
4/04												zzzzz		
4/06			xxxxxxxxxxxx											

xxxxx - Makaleha Stream
zzzzz - Kealia Estuary

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were conducted along with six short observational periods in Kealia Estuary from 3/16/90 - 4/6/90.

Makaleha Stream

Good habitat for the Koloa was only found in certain stretches of the stream channel in Makaleha. From the intake and weir (525 foot elevation) a dense, closed canopy of hau (<u>Hibiscus tiliaceus</u>) extends upstream several hundred feet. This dense riparian growth gradually gives way to a similarly dense, closed canopy of roseapple (<u>Syzygium jambos</u>) extending to an elevation of 600 feet. This lower section of Makaleha Stream is therefore characterized by a dense, low tangle of riparian canopy and is probably unsuitable habitat for the shy, low-flying Koloa.

Good Koloa habitat however is available where the canopy opens above this 600 foot elevation and is likely the area where the Koloa was sighted previously by Bruner. This area begins an estimated 300-400 feet (92-122 meters) downstream of the Makaleha Springs site and extends upstream of this area another several hundred feet where a dense growth of hau (Hibiscus tiliaceus) again nearly closes out the stream channel. The elevation of the upper limit of this area was recorded at 800 feet.

This area appears well suited to the Koloa since in addition to the open canopy, there are varied sources of food and extensive undergrowths of basket grass (Oplismenus hirtellus) available as nesting grounds. Native vegetation is first noticed in this area with plants such as mamaki (Pipturus albidus), 'ie'ie (Freycinetia arborea), and 'ohi'a-lehua (Metrosideros collina polymorpha) being present in the riparian vegetation. Native damsel flies (Megalagrion sp.) are common as are many other aquatic insects. Native freshwater Limnaeid snails are common on the rocks within the spring, as are native 'opae-kala'ole (Atyoida bisulcata). Within the pool that receives spring water were found two species of endemic freshwater fish, the 'o'opu-nakea (Awaous stamineus) and the 'o'opu-alamo'o (Lentipes concolor). It is not known if any of these serve as important sources of food for the Koloa although it is certainly a possibility.

Above this area the gradient of the stream increases dramatically rising 100 feet through a distance of approximately 150-200 feet (31-61 meters). It is unlikely that the Koloa would prefer such areas although the alien cattle egret (Bulbulcus ibis) and the indigenous Aukuu or Black-crowned Night Heron (Nycticorax nycticorax hoactli) were both observed in this area.

Upstream of this steep-gradient area, the channel levels out and again opens into good Koloa habitat which extends into the "right" (determined facing upstream) canyon to the terminal pool (1000 foot elevation). The smaller canyon to the "left" has a narrow stream channel that is characterized by a closed canopy composed primarily of yellow guava (Psidium guajava). The better Koloa habitat therefore extends into the "right" canyon. Present in riparian vegetation at this higher elevation area are uncommon Hawaiian plant endemics such as the lobelioid Cyanea gayana, the loulu palm (Pritchardia sp.), olona (Touchardia latifolia) and Pisonia umbellifera. Endemic 'o'opu and 'opae are still found in the stream at this elevation. A White-tailed Tropicbird (Phaethon lepturus dorotheae)was observed soaring the cliff face of the "left" tributary.

Although good Koloa habitat does exist in Makaleha Stream at the spring area and also in the stream's higher reaches, no sightings of this endangered waterbird were made in any of the field trips during the study period. Searches through the ground cover in areas of good habitat revealed no Koloa nests or any evidence of their presence.

Kealia Estuary

Six short observational periods were made in the marshlands at sea-level where Kapaa River empties into the ocean (table 1). One unconfirmed sighting of a Koloa in flight was made after sunset on 3/20/90 however darkness prevented a clear view of the animal. Other than this, no sightings of a Koloa were made indicating that if anything, the Koloa is an infrequent visitor to the Kealia marshlands at least during the study period.

Other endangered waterbirds however are probably permanent residents of the marsh. At least two Hawaiian coots (<u>Fulica atra</u>) were always present during the observational periods in the water or foraging through the grass on the stream banks. The Hawaiian Gallinule (<u>Gallinula chloropus</u>) was also observed.

CONCLUSIONS

Based on the findings of this study, it seems unlikely that the Koloa is a permanent resident of the Makaleha Stream system or that there is a breeding population there. The fact however that good habitat is available and that the previous consultant did find a Koloa, may suggest that the area is occasionally used by Koloa. It is possible that Koloa may utilize Makaleha Stream as well as the other high mountain tributaries of Kapaa Stream (Moalepe and Kapahi) on an infrequent but consistent basis throughout the year however a longer study period is required to determine this. It should be stated also that the findings of this study really can only be applied to the present study period and that extrapolation of the results may lead to erroneous conclusions.

Swedberg (1967) locates a Koloa nest in a map in his report that may be within the Makaleha Stream area however without his field notes its exact location is very difficult to ascertain. The present study period is well within the suggested optimum breeding period of December to May which tends to support the conclusion that a breeding population does not reside there however as stated previously, it is entirely possible given the existing habitat that breeding does occur at different times of the year.

A number of factors may be contributing to the less frequent use of Makaleha Stream by the Koloa. One of these is the observation that the canopy is becoming increasing closed by aggressive riparian vegetation such as hau (Hibiscus tiliaceus) which forms a dense tangle that rapid, low flyers like the Koloa probably avoid. Given the "nuptial flight" behavior during mating described by Swedberg (1967), the closed canopy may also be a factor interfering with the bird's breeding behavior.

Other inimical factors may interfere with the Koloa's use of Makaleha Stream. Barking sounds from high in the valley along with tracks on the trail may indicate a feral dog population in the valley which would certainly prey on Koloa. The Aukuu or Black-crowned Night Heron (Nycticorax nycticorax hoactli) observed in the stream is also believed to be a predator of Koloa ducklings (Swedberg 1967). The aggressive Cattle Egret (Bulbus ibis) observed on several occasions in the stream is definitely a competitor of the Koloa and may also be a predator on ducklings as well. Increased human disturbance by hunters, hikers and the like is probably another factor reducing the suitability of the stream to the Koloa.

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APPENDIX F

ARCHAEOLOGICL RECONNAISSANCE

Cultural Surveys Hawaii

CULTURAL SURVEYS HAWAII
Archaeological Studies
Hallett H. Hammatt, Ph.D.
49 S. Kalaheo Avenue
Kailua, Hawaii 96734
(808) 261-8293

October 20, 1986

Mr. Glenn Yamamoto
Portugal and Associates, Inc.
4334 Rice Street, Suite 204
Lihue, Kauai, HI 96766

Subject: Archaeological Planning Reconnaissance of the Mokaleha Stream for Makaleha Springs Water Source Development, Kapa'a, Kauai

Dear Glenn:

At your request an archaeological reconnaissance was conducted for the above project on October 1, 1986, for the purpose of locating and evaluating archaeological sites within the project area and assessing impact of the proposed project.

Proposed Project

It is my understansding that the project includes the construction of a spring catchment system at the Upper Makaleha Springs with a 4,000 foot long pipeline from the Springs to the existing 1 million gallon water tank (see enclosed map). This may involve some road construction at least partially up the valley.

Description of Project Area

Makaleha Valley is a short and steep "V shaped" tributary valley to Kapa'a Stream drainage. It originates in the Makaleha Mountains at the northeast slope of Kapa'a Valley. Farm settlements and pastures of the Kapa'a Homesteads are on the north slope of the main valley. The makai portion of the project area is marked by a million gallon water tank at the end of Kahuna Road. A well maintained trail used by ditch maintenance workers, hunters, and stream fishermen leads to the Lihue Plantation diversion. This is a concrete dam in the stream itself with a diversion tunnel. Above this point the trail crosses the stream and the valley narrows. The trail leads through thick stands of bamboo, hau, fern, guava and ginger generally on the south side of the stream. The valley continues to narrow and the slopes become steep along the trail towards Makaleha Springs. Ground visibility was somewhat limited except under mature forest cover. One small tributary enters the main stream directly below the Springs from the west side.

Previous Related Studies

To our knowledge the only previous archaeological study which relates to this specific area is W. C. Bennett's 1928-1929 Survey of the Island of Kauai (Archaeology of Kauai, Bishop Museum Bulletin 80, 1931).

Bennett's site 110 is described as taro terraces and bowl at the back of Kapaa Homesteads. "In the foothills of the mountains are many little valleys which contain taro terraces. Single rows of stone mark the division with some 2 foot terraces. Under a large Mango tree was found a bowl." (page 128). He refers to taro terraces and house sites at Kopahi (page 73) which is considerable distance down Kapaa Valley from the project area. Although no terraces were found in the project area itself, they could have occurred in the more gently sloping land nearer the stream confluences in Kapaa Homesteads makai of the project area. They could also occur on the slopes at the mouth of Makaleha Valley south of the proposed pipeline.

Reconnaissance Results

The approximately 4,000 foot long project area was surveyed by 2 archaeologists. It was observed that the route of the proposed pipeline is steep sided and susceptible to flooding. The slopes were examined for possible terracing and other archaeological features but none were observed. The valley slopes appear to be too steep and too constricted to make agricultural terracing practical. If terraces or other archaeological features were present, they would have been destroyed by flooding or covered by slopewash. On the basis of our fieldwork, it appears that the proposed pipeline construction would have no impact on archaeological resources and no further archaeological investigation is recommended. There is a possibility that ancient terraces may occur at the mouth of the valley on the west side of the stream [redacted]. If this area is to be impacted by construction, it should be examined first by an archaeoloagist.

If there are any questions concerning the above, please contact me. Thank you very much.

Sincerely,

Hallett H. Hammett

Hallett H. Hammatt, Ph.D.

HHH:mt